INSECT AND DISEASE CONSIDERATIONS
FOR DEVELOPMENT OF THE GALLATIN NATIONAL FOREST PLAN

by

Mark D. McGregor, Oscar J. Dooling and William Wulf

INSECT AND DISEASE CONSIDERATIONS
FOR DEVELOPMENT OF THE GALLATIN NATIONAL FOREST PLAN

by

Mark D. McGregor, Oscar J. Dooling and William Wulf

FOREST INSECT AND DISEASE CONSIDERATIONS TO BE INCORPORATED INTO THE PLANNING PROCESS

Those insect and disease pests capable of seriously affecting resource allocations and subsequent outputs must be identified early in the planning stage. Forest Pest Management has the responsibility to assist land managers in identification of major forest pests, provide biological information about the pest, and suggest alternatives for their management where appropriate.

Major Insect and Disease Pests on the Gallatin National Forest

Major insect and disease pests identified as concerns in the forest planning process are ones which significantly affect present management policy or have the potential to affect future management. Presently the pests impacting management policy on the Forest are mountain pine beetle in lodgepole and whitebark pine, and western spruce budworm in Douglas-fir, subalpine fir, and Engelmann spruce.

Others identified as having the potential to affect management strategies within the planning process are:

Insects	Diseases
1. Douglas-fir beetle	1. Dwarf mistletoe
2. Spruce beetle	2. Root disease
	3. Stem rusts
	4. Stem decays

Following is a description of those pests including areas of damage, present or potential damage attributable to them, and possible management strategies.

MOUNTAIN PINE BEETLE IN LODGEPOLE AND WHITEBARK PINE STANDS

Past Outbreaks

Mountain pine beetle infestations were first reported in 1931 on the Gallatin National Forest. More than 20 million trees were killed on 1.6 million acres through 1939 when the epidemic died out. During this period, infestation occurred in about the same area as the present one. However, mortality of whitebark pine was greater than lodgepole pine in many stands. The most severe losses occurred in lodgepole pine stands of the Mill Creek drainage. Secondary bark beetles killed a greater proportion of the lodgepole pine, particularly during the last 3 to 4 years of that outbreak. Factors such as windthrow, snowbreakage, and small diameter trees contributed to the population buildup of secondary bark beetles.

Present Situation

The current epidemic developed in lodgepole pine stands on the Bozeman-Gallatin and Hebgen Lake Ranger Districts in 1969 and 1970 respectively. Epidemic infestation now occurs on the Gardiner and Livingston Ranger Districts and is rapidly developing in susceptible stands on the Big Timber Ranger District. Aerial survey estimates showed 455,730 acres of lodgepole pine type and high elevation whitebark pine type were infested on the Gallatin National Forest in 1981. About 180,282 acres of lodgepole pine type are infested on privately owned lands.

Bozeman-Gallatin Ranger District

Infestation encompasses 255,670 acres of high hazard lodgepole pine type. Both lodgepole and whitebark pines have been depleted in stands in tributaries of the lower Gallatin River drainage. However extensive mortality will occur in tributaries of the upper Gallatin River drainage, in major drainages across the Gallatin Face, and in the Bridgers for about 4 more years.

Hebgen Lake Ranger District

Approximately 124,000 acres of lodgepole pine type have been infested since 1970. Most of the susceptible lodgepole pine in low elevation stands have been killed and beetle populations are declining. Additional tree mortality will occur for 3 to 4 more years, then subside.

Gardiner Ranger District

Infestation was first detected on 380 acres in 1979. Beetle populations have now infested 25,571 acres of lodgepole pine type on federally managed lands.

Livingston Ranger District

Approximately 49,180 acres of high hazard lodgepole pine type have been infested during the past 5 years. Tree mortality increased in older epicenters and infestation spread eastward.

Big Timber Ranger District

New infestation centers ranging from a few infested trees to 30-50 trees/group occurred on 1,309 acres of lodgepole pine type.

Factors Important to Tree and Stand Susceptibility

Mountain pine beetle presents the most serious threat to growing lodgepole pine throughout its range. Populations of the beetle periodically increase and, over the course of an infestation, large diameter trees are usually infested and killed first each year, as well as over the life of the infestation. During this period more than 80 percent of the merchantable volume can be killed.

The frequency of epidemics is related to site quality, with stands on more productive sites becoming susceptible more rapidly than those growing on poor sites. The frequency and intensity of outbreaks in lodgepole pine are related to average tree age and diameter, and elevation-latitude of the stand (Cole and Amman 1980). Lodgepole pine stands are considered high hazard when average stand age is more than 80 years old with an average tree diameter exceeding 8 inches d.b.h. Tree mortality is inversely related to increasing elevation-latitude.

Phloem thickness within trees of a stand determines whether the beetle can maintain or increase its numbers. Because of the strong positive correlation between phloem thickness and tree diameter, and the relative ease with which diameter is measured, average tree diameter is used to determine stand suseptibility. Trees growing on good sites (productivity class 5 = 50-80 cubic ft/ac/yr) will have thicker phloem and when infested a greater brood:parent ratio than trees on poorer sites (productivity class 6-7, 20-49 cubic ft/ac/yr and less than 20 cubic ft/ac/yr respectively).

Stands of lowest density have the greatest proportion of the large diameter trees with thick phloem. Therefore, beetle production will be greater in trees of succeedingly larger diameter classes in more open stands. Mortality in these stands will be proportionately greater than in dense stands.

Intensity of infestations and subsequent numbers of trees killed differ with habitat type (h.t.) (Roe and Amman 1970; McGregor 1978). In northwestern Wyoming and southeastern Idaho, the *Abies lasiocarpa*/*Vaccinium scoparium* (ABLA/VASC) h.t. contained the least beetle activity--44 percent--and occurred between 6,500-8,500 ft. elevation;

stands in Abies lasiocarpa/Pachistima myrsinites (ABLA/PHMY) h.t. had the greatest beetle activity--92 percent-- and occurred between 6,700-7,800 ft. elevation; and the Pseudotsuga menziesii/Calamagrostis rubescens (PSME/CARU) h.t. showed 64 percent infestation and occurred between 6,000-7,800 ft. elevation.

Mortality of lodgepole pine from mountain pine beetle was related to habitat types (Pfister et al. 1977) and losses were found to decrease in the following order--Douglas-fir, spruce, subalpine fir, and lodgepole pine climax (McGregor 1978). There was little difference among Douglas-fir, spruce, and some of the subalpine fir types with mortality ranging from 40 to 42 percent of the lodgepole pine basal area in trees 8 inches d.b.h. and larger. Variation in mortality between habitat types follows what has been previously established; the more favorable the site, the thicker the phloem and consequently the greater the tree mortality provided trees are large diameter and 80 or more years old.

Some researchers have found that epidemics may not develop even in large diameter, old age lodgepole pine unless current (CAI) and mean annual increment (MAI) intersect, or until there is a rapid decline in CAI.

There appears to be an inverse relationship between tree mortality and incidence of dwarf mistletoe infection. Stands having trees with the least mistletoe infection suffer the greatest mortality. Because of the beetles' strong preference for large diameter thick-phloem trees, brood production markedly declines in trees heavily infected with mistletoe (McGregor 1978). Roe and Amman (1970) concluded that tree mortality was more severe in relatively mistletoe-free stands, and that trees in those stands had thicker phloem than infected trees. Trees having medium-to-heavy mistletoe infection possess thinner phloem than uninfected trees; consequently, beetle production declines in heavily infected trees.

Stands depleted by the beetle and not subjected to fire are eventually succeeded by more shade-tolerant species--Douglas-fir at lower elevations and subalpine fir and Engelmann spruce at higher elevations (Amman 1977). With each beetle infestation, the large, dominant lodgepole pines are killed. After the infestation, both residual lodgepole pine and shade-tolerant species increase their growth. When trees again become susceptible, another infestation occurs. This cycle is repeated at 20- to 40-year intervals depending upon tree growth, until lodgepole is eliminated from the stand.

Accumulations of dead material resulting from periodic beetle infestations can result in very hot fires. Such fires eliminate competitive species, and serotinous cones of lodgepole pine usually seed burned areas abundantly. Following regeneration, the mountain pine beetle/lodgepole pine interactions would be similar to those described without fire. Fires may interrupt succession at any time, reverting the stand to pure lodgepole pine.

In other stands, lodgepole pine may be more persistent or even climax. In such cases, the forest consists of trees of different sizes and ages, ranging from seedlings to mature and overmature trees. In these forests, the beetle infests and kills trees as they mature. Openings created as a result of larger individuals being killed are seeded in by lodgepole pine.

This cycle is repeated as younger trees reach maturity, are killed, and replaced. This results in a mosaic of age and size classes in these stands. This may result in more chronic beetle infestations due to a continual source of small susceptible groups of lodgepole pines. Tree mortality may be less per acre during these infestations than occurs in even-aged seral stands.

Assessing Stand Susceptibility

Systems for assessing susceptibility of individual stands to mountain pine beetle outbreaks have been based on (1) historical evaluation of the frequency and intensity of infestations within a Region; (2) correlation of damage intensity and habitat type; (3) evaluation of damage by climatic zones; (4) host tree characteristics including diameters and phloem thickness; (5) competition, periodical growth rate, and basal area; (6) physiological maturity; and (7) various combinations of the foregoing (McGregor et al. 1981). Hazard rating systems recognize that beetle and trees have different limiting factors.

The method of assessing stand susceptibility we recommend is based on three factors: (1) climatic suitability (elevation and latitude) of the lodgepole pine stand for outbreak development; (2) average age of the lodgepole pine stand more than 5 inches d.b.h.; and (3) average diameter of lodgepole pine greater than 5 inches d.b.h. (Amman et al. 1977).

The rationale in using these factors follows: Beetle populations do well at low elevations where temperatures are optimum for development. Brood development slows as elevation increases until at high elevations 2 years may be required to complete a generation (Amman 1973). Delay in development frequently results in beetles entering winter in stages that are more prone to mortality. In addition, beetles in a 2-year cycle are subjected to mortality factors for a longer period of time than during a 1-year cycle. Adverse effects on the population associated with increasing elevation are reflected in reduced tree mortality.

Climatic suitability is based on observed lodgepole pine mortality to mountain pine beetle for many different elevations and latitudes from Colorado to the Canadian border (figure 1).

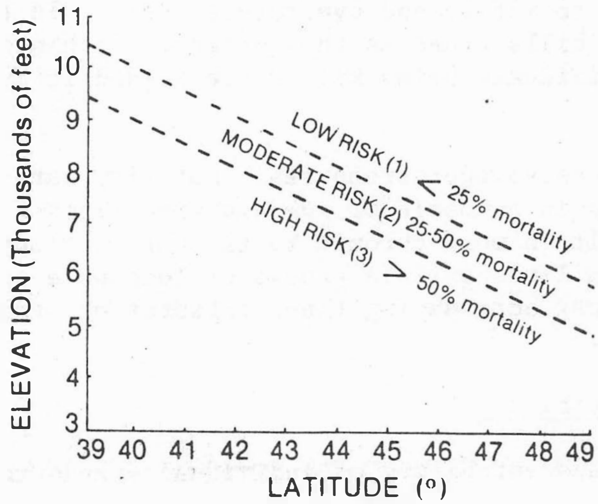


Figure 1. Risk of mountain pine beetle infestation in lodgepole pine can be defined by zones of elevation and latitude. Percent mortality is for trees 8.5 inches d.b.h. and larger (Amman et al. 1977)

Average stand age is not a measure of tree vigor, but rather of phloem suitability. Young lodgepole pine less than 60 years of age have phloem more spongy and resinous than older trees. Such trees tend to dry excessively after being infested. These characteristics are less apparent in lodgepole pine 60 to 80 years old. Lodgepole pine more than 80 years old tend to have phloem that is considerably firmer and contains fewer and smaller cortical resin ducts. Such trees generally dry slower than young trees, thus providing adequate moisture throughout beetle development (McGregor et al. 1981).

Average d.b.h. of lodgepole pine in the stand is used because of the beetles' strong preference for large diameter trees. These trees generally have thicker phloem and dry slower than small diameter trees. Brood production is strongly influenced by phloem thickness and tree moisture (Cole et al. 1976). Average d.b.h. less than 7 inches presents a low hazard, 7-8 inches a moderate hazard; and greater than or equal to 8 inches a high hazard. Of these categories, only lodgepole pine stands with an average d.b.h. more than 8 inches can be expected to have a sufficient number of large diameter trees for the beetle population to build up and be sustained. The first two hazard categories have fewer large trees resulting in lower beetle populations and hence reduced tree mortality.

Hazard rating information is obtained from standard stand exam data. For small stands less than 20 acres, a systematic random or grid sample of 10

variable plots (10 BAF) is recommended. For larger stands, 20 variable plots are suggested. Age is obtained from increment cores taken at breast height from two trees nearest to plot center that are more than 5 inches d.b.h. Average diameter for the stand is determined from measuring all lodgepole pine trees 5 inches d.b.h. and larger within each plot.

Risk values have been assigned to each of three factors--climatic suitability, average tree age, and average d.b.h. (table 1).

Table 1.--Hazard rating lodgepole pine stands for the risk of mountain pine beetle infestation is obtained by multiplying the following factors (1=low; 2=moderate; 3=high) for elevation and latitude, average age, and average d.b.h., the stand's susceptiblity classification is obtained; 1=1 to 6; moderate=8 to 18; high=27. 1/ (Amman et al. 1977)

	RISK CLASSIFICATION		
	Low = 1	Moderate = 2	High = 3
Elevation-latitude	High	Moderate	Low
Average age (years)	<60	60-80	>80
Average d.b.h. (inches)	<7	7-8	>8

1/ One exception to these ranges occurs when all three factors are rated moderate, but the value (8) falls within the range of low hazard. This should be considered moderate hazard for outbreak potential.

Results of hazard rating lodgepole pine are shown in table 2.

Table 2.--Hazard rating of lodgepole pine stands for potential mountain pine beetle epidemics, Gallatin National Forest.

	Acres 1/ by hazard class		
Ranger District	Low	Moderate	High
Big Timber	4,745	6,376	2,053
Livingston	16,437	15,776	2,025
Gardiner	17,010	23,227	918
Bozeman-Gallatin	56,176	64,678	8,409
Hebgen Lake	22,233	36,541	26,365
Total acres	116,601	146,598	39,770

1/ These acres are only those Forest Service stands classified as commercial forests.

Acreage figures were derived from information on timber type maps and updated from aerial photos where available. A more accurate hazard rating can be obtained from stand exam data which would increase the amount of acres classed high hazard. As many or more additional acres in each hazard class, particularly high hazard, occur on privately managed lands. Once these data are obtained, the method developed by Amman et al. (1977) can be used for rating stands for susceptibility to outbreaks. Stand data can be run through the computer program INDIDS and Cole's mountain pine beetle model to project stand mortality over time.

INTEGRATING CONTROL STRATEGIES FOR MOUNTAIN PINE BEETLE WITH MANAGEMENT OF OTHER RESOURCE VALUES IN LODGEPOLE PINE STANDS

Management objectives should be directed toward preventing or at least substantially mitigating the development of epidemic infestation levels of mountain pine beetle in extensive lodgepole pine stands. This can be accomplished silviculturally by converting large-scale, single-aged stands into a mosaic of smaller even-aged stands of different ages, through carefully scheduled regeneration harvests and subsequent intermediate cuttings.

Beetle populations can be managed by a process in which known aspects of the mountain pine beetle/lodgepole pine system are evaluated and weighed to provide the resource manager with information for keeping damage from mountain pine beetle to tolerable levels. This can be accomplished through a process called integrated pest management (IPM). To be effective, an ecological approach including prevention, suppression, and post-suppression activities must be integrated with management of other forest resources.

Integrated management of mountain pine beetle in lodgepole pine forests should usually be directed toward prevention. Prevention is the best approach because techniques are more effective, economical, environmentally acceptable, and compatible with management of other forest resources. However, the full array of available pest management responses must be considered through an orderly process to insure sufficient, cost-effective pest management prescriptions.

Management Options in Commercial Forests

Pure, Even-Aged Lodgepole Pine Stands - Where composition is pure lodgepole pine and form is even-aged, valid silvicultural practices are generally limited to (1) stocking control in young stands, (2) organized clearcutting in blocks to create age, size, and species mosaics from mature stands, (3) salvage cutting to mitigate losses in stands under attack, and (4) sanitation cutting in some situations.

Stocking Control - This is an extremely important practice in pure, even-aged lodgepole pines. It allows sustenance of good stand vigor and the direction of stand growth toward moderate tree size and rotation objectives (D. M. Cole 1978). Stocking control by age 25 (preferably by age 15) to a spacing of about 10- by 10-feet results in culmination of mean annual cubic volume increment on medium-to-good sites at about age 80--with average stand diameters of about 10 inches d.b.h. (D. M. Cole 1973). Improved vigor of trees in managed stands will prevent infestation by *Ips* sp., *Pityogenes* sp., and other secondary bark beetles that may assist mountain pine beetle populations in surviving during endemic levels.

Block Clearcutting - Organized clearcutting in small-to-moderate sized blocks creates age and size mosaics from extensive, pure, even-aged stands and is a highly recommended practice (Roe and Amman 1970; Amman 1976). Timely surveys and maps of stand growth and volume, site quality, and other hazard-related factors such as phloem thickness, elevation, stand structures and form, composition and ecological habitat type are essential for organized block clearcuts to be effective. Schedules for block clearcutting as a preventative measure should be coordinated with other multiple use management objectives. In areas proposed for clearcutting where probability for loss is high, future damage can be reduced by directing regeneration of sites to patterns of alternating species among blocks or to a pattern of mixed species within blocks (D. M. Cole 1978). Models for predicting stand growth have been developed for determining the effects of prescribed management activities (Stage 1973). Caution is needed, however, in modifying such models to forecast the interaction of the mountain pine beetle and lodgepole pine forests over time. Without full consideration of biological principles, logic, and beetle behavior, erroneous conclusions can be drawn.

Salvage and Sanitation Cutting - Sanitation and salvage cutting should be justified either directly by timber economics or indirectly through protection of other resources in order for them to qualify as actual loss reduction practices (D. M. Cole 1978). Salvage cutting should be planned and administered as a conscious silvicultural practice to protect other resource values. Time between tree killing and salvage cutting should be minimal to prevent wood deterioration.

Sanitation cutting to remove highly preferred large diameter infested trees from high hazard stands may slow mortality. However, sanitation cutting will not significantly change stand structure, and beetles will seek out and infest residual large diameter lodgepole pine particularly in some stands. Surveys to inventory stand structure may permit successful selective cutting and prevent or greatly reduce beetle infestation for several years. Sanitation cutting is expensive and must be carefully coordinated to prevent spread of beetles into other stands along haul roads or from infested logs decked at sawmills.

Sanitation cutting must also take into account any dwarf mistletoe or cutting may leave to many infected residuals.

PURE, UNEVEN-AGED LODGEPOLE PINE STANDS AND MIXED SPECIES STANDS

A high percentage of pure stands contain from two to several age classes and are located near and east of the Continental Divide. Also many uneven-aged lodgepole pine stands are mixed species stands. A common situation is a mature or overmature lodgepole pine overstory, with a mixture of smaller shade-tolerant species and some younger lodgepole pine in the understory. The size and mixture of the understory depends largely on the pattern of openings created in the overstory by insects, diseases, and climatic factors (D. M. Cole 1978).

Another common mixed stand situation involves one or more other species in the overstory with lodgepole pine, with an understory of one or more climax species. This situation is common and occurs west of the Continental Divide in ranges of other seral or relatively shade tolerant species such as Douglas-fir, Engelmann spruce, western larch, and western white pine. Near and east of the Continental Divide, mixed overstory stands are usually well advanced toward succession of subalpine fir, Engelmann spruce, or Douglas-fir with lodgepole pine in a decadent condition.

Stocking Control, Clearcutting, and Salvage Cutting - For uneven-aged stands and for similarly described stands (Tackle 1955), the preventive practices mentioned for pure, even-aged lodgepole pine stands are also feasible. For example, mature even-aged or mixed stands with a significant component of large lodgepole pines in the overstory can be treated by block clearcutting as a preventative. If already infested, mortality can be minimized by salvage logging.

Immature uneven-aged and mixed species stands are candidates for stocking control, with species discrimination possible in mixed species stands (D. M. Cole 1978).

In older mixed species stands we can discriminate against lodgepole pine by cutting only the larger trees. This can be considered a valid practice in regulated forests only if the residual stand is of sufficient vigor and stocking to maintain stand growth near the yield capability level of the site. However, value of the volume removed must exceed removal costs, unless indirect benefits of beetle management warrant subsidization.

Partial Cutting Practices - Partial cutting of larger lodgepole pine reduces beetle infestation in susceptible stands (Hamel and McGregor 1976; Cole and Cahill 1976; Hamel 1978). Amman (1967) concluded that

partial cutting is recommended where timber values are primary, and applies only where (1) a small portion of the lodgepole pine have the larger diameter and phloem thickness categories conducive to beetle buildup, and (2) residual trees would be numerically adequate and vigorous enough to maintain productivity of the stand.

Basal Area Cuts - Usually, only stands having a healthy component of other species can provide a residual component capable of maintaining volume productivity. Discriminating against the beetle-preferred lodgepole pine in such stands can be silviculturally acceptable, but the volume involved may not be economical to remove. Conversely, removal of sufficient additional volume including other species may overcut the stand. The volume of beetle-preferred trees marked for removal may not be enough to pay for the road system. Thus, maintaining growing stock must be considered important enough to subsidize development costs if mortality is to be reduced in inaccessible stands where only a small portion of the volume is susceptible at any one infestation cycle (D. M. Cole 1978).

Partial cuts might be justified in a mixed species stand just coming under attack, if attacks on adjacent extensive stands could be delayed until they could be silviculturally treated. This would be accomplished if buildup of the beetle population in the mixed species stand was postponed or effectively slowed by removing a portion of the high risk lodgepole pines (D. M. Cole 1978).

In selecting trees for partial cutting, only trees having a high probability of being attacked should be removed, and seed should be collected from the most vigorous, large trees and saved for site regeneration. Careful attention should also be paid to the problem of dwarf mistletoe and windthrow when considering partial cuts.

CONTROLLED BURNING IN NONCOMMERCIAL FORESTS

In National Parks and primitive and wilderness areas, high value is placed on maintaining a natural ecosystem. Mortality is generally considered in terms of impairment of the visual resource and increased costs to maintain convenience and safety for recreationists. Management in these areas is thought of as good housekeeping rather than silvicultural practices. One exception is fire management (D. M. Cole 1978). Fire is an integral part of the ecology of lodgepole pine forests and, along with mountain pine beetle, has been largely responsible for maintenance of lodgepole pine as a widespread forest type. Natural fires have been suppressed in many park and wilderness areas, so that dead wood resulting from epidemics accumulates until large hot fires occur. Such fires are more destructive than ones that would have otherwise occurred if fires had not been suppressed, and they tend to perpeutate future extremes in

the mountain pine beetle/lodgepole pine/fire interaction (D. M. Cole 1978). This cycle can be moderated if a deliberate program of prescribed fire management is instituted.

Reliable surveys and maps of stand age and size and fuels can be used to develop a plan to allow some fires, once started, to burn to create a mosaic of regenerated stands within the extensive areas of large timber that have developed.

Prescribed burning offers real silviculture advantage over trying to manage naturally occurring fires in such high hazard situations as beetle-infested areas.

Tree Protection

Individual tree protection is feasiable for high value trees in recreation areas, administrative sites, and around homes. Trees can be sprayed with Sevimol-4 R, 2 percent mixture. A single application before flight and attack will protect trees for up to 2 years. The use of such chemicals will vary from State to State. Information on their availability can be obtained from Forest Pest Management units at Regional Offices.

Planting trees of different species should also be considered in high use recreation areas, and when planning such facilities as campgrounds, administrative sites (where lodgepole pine has been killed). Thus, shade, esthetics and public safety will be enhanced.

Special Management Considerations

Extensive stands of whitebark pine occur above 7,800 feet elevation in many areas. Infestations often begin in susceptible lodgepole pine stands at lower elevations develop to epidemic status, and eventually infest adjacent whitebark pine stands at higher elevations.

These stands are classified as high areas, unregulated, economically and physically inaccessible, growing season is short, frost-free days are less than 30/year, estimated annual precipitation ranges from 69 to 120 inches with 60 to 90 percent running off. Soils are shallow, and timber productivity is low (<20 cubic feet/acre/year). Trees range up to 30 inches d.b.h. and can have two to four 16-foot logs/tree. Some stands are 450-500 years old. Habitat types are *Abies lasiocarpa*/*Luzula hitchcockii* and *Abies lasiocarpa*/*Vaccinium scoparium* (Wilson 1979).

Current technology does not encompass harvest or regeneration systems that insure workable silvicultural prescriptions. However, we can be faced with extensive areas of mortality in whitebark pine stands.

Many of these stands are uneven-aged and are represented by whitebark pine, subalpine fir, and some spruce at lower elevations. After whitebark pine is killed and snags fall, subalpine fir and spruce may be windthrown and add to fuel loading. Because of fuel loading, decomposition rate is about one-half that of production.

Elevation influences decay of these residues in several ways. Precipitation, much in the form of snow, increases with elevation; the sun's rays have a stronger effect at high elevations; and day and night temperatues are more extreme. Compaction of piled and scattered slash by snow at higher elevations results in greater contact between ground and slash. On mesic sites, residues may become waterlogged, and decay impeded. However, on most other sites, decay will be promoted by ground contact. In general, temperatures throughout the year are cooler than at lower elevations; thus, there are fewer days when temperatures are optimal for decay to occur. Where snow remains until early summer, both temperature and moisture conditions are unfavorable for decay of residues most of the year. On dry south and west slopes at higher elevations, the stronger effect of the sun promotes rapid drying of the soil surface and residues, resulting in case hardening of exposed wood (Wilson 1979).

Usually the longer fire is postponed, the more intense it becomes because fuel accumulates over longer periods. Large blocks of contiguous fuels are the primary cause of many fires becoming damaging and costly. Fuel and fire breaks are recommended to isolate hazardous fuels, high-risk fuel areas, protect recreation or high value areas, and reduce the potential of fire to spread over large areas. Catastrophic fires occurring in high elevation whitebark pine stands result in slow recovery rates and will undoubtedly cause additional constraints on the commercial forest land base.

Guidelines for Coordination with Wildlife

Lodgepole pine forests also support highly valuable wildlife species which include the West's two most popular and valuable game species--the Rocky Mountain elk and mule deer. In addition the grizzly bear, a federally classified threatened species, and numerous nongame wildlife species are found in lodgepole pine forests. As a result, there has been considerable controversy regarding the management of lodgepole pine and its impacts on wildlife. Attention must be given to integrating wildlife habitat requirements with management of lodgepole pine stands.

Timber harvest to reduce beetle impact can affect wildlife by (1) changing the arrangement and abundance of food and cover, (2) increasing human disturbance as a result of road access, and (3) altering key habitat components such as moist sites.

Regional direction describing wildlife considerations are presented in a May 1 letter from the Regional Forester, file designation 1920 - 2650.

WESTERN SPRUCE BUDWORM

By Bill Wulf, Silviculturist

Present Situation

In 1981 spruce budworm defoliated 68,607 acres of Douglas-fir type on the Gallatin NF and adjacent State and private lands.

The Big Timber RD has 31,747 acres of National Forest lands infested, followed by Livingston RD with 2,133, Gardiner RD with 4,103, Bozeman-Gallatin RD with 3,908 acres, and Hebgen Lake RD with 1,840 acres. Approximately 24,876 acres are infested on other ownerships.

The most severe defoliation is occurring on drier Douglas-fir habitat types at low to mid-elevations. In those stands many of the understory and smaller pole size trees have been killed or severely damaged. The exception is fringe areas where Douglas-fir trees have invaded the grasslands. These small trees, less than 10 feet high, are not usually damaged.

Management Alernatives

The two approaches to spruce budworm management are direct and indirect control. Direct control involves application of registered insecticides such as malathion, carbaryl (Sevin ^{R}) and acephate (Orthene ^{R}). A microbial chemical, *Bacillus thuringiensis* was pilot tested for effectiveness against spruce budworm in 1981.

Indirect control involves use of silvicultural methods to alter stand susceptibility to budworm. Reducing stand vulnerability involves manipulating habitats to regulate insect numbers.

Chemical Strategies

Chemicals have been the mainstay of efforts to "control" budworm. Absolute control has not been possible even with persistent chemicals such as DDT. Chemical treatment is performed where and when the resource values in jeopardy warrant the economic and social costs of spraying. Relatively safe and effective chemicals are registered and technology is available for individual tree and large forested area application. Managers must anticipate future damage likely to occur as well as predict effectiveness of chemical treatment. Because budworm seldom kills merchantable trees over extensive areas, damage associated with growth reduction and topkill seldom justifies large scale spraying. Chemical treatment disturbs a self-regulating ecosystem and unless natural population factors change, the sprayed population may rebound

to previous levels. Where both risk of unacceptable damage and resource values are high, such as in seed orchards or developed recreation areas, chemical treatment may be warranted and is usually successful in achieving protection.

Biological Strategies

Biological strategies involving manipulating of parasites, predators and disease pathogens are largely undeveloped. The biological strategy on the verge of operational status is the use of Bt (Bacillus thuringiensis). Certain viruses also show promise.

Biological agents are environmentally safer than insecticides, but their effectiveness has been erratic, and they cost more. Carryover in subsequent generations has not been thoroughly evaluated.

Silvicultural Strategies

Silvicultural strategies involve cultural treatments of host stands to reduce or prevent resource losses. These strategies are generally undeveloped or untested but have been considered in budworm management in the design of stand treatment prescriptions with many examples of success.

Silvicultural strategies are "salvage/presalvage" and "reducing stand vulnerability."

Salvage of dead trees and living trees which will probably not recover from defoliation may be important. Since little mortality occurs directly from budworm infestations, salvage volumes per acre are likely to be low with associated high logging costs. Presalvage of trees which are expected to die or become damaged is implemented prior to an outbreak or before significant damage is apparent. Salvage and presalvage are suitable only for accessible stands where mortality and severe damage is concentrated.

Stand susceptibility to budworm is a function of species composition, genetic diversity, density, vigor, and size structure. Host species vary in their ability to cope with defoliation. For example, subalpine fir shows more top kill and radial growth reduction than associated Douglas-fir when subjected to repeated budworm defoliation. Damage vulnerability is generally related to shade tolerance; more shade tolerant trees suffer greater damage in mixed species stands. Trees of the same species and size adjacent to each other may display different levels of defoliation, suggesting genetic resistance.

Stand density usually describes the absolute number of trees which are exposed to budworm feeding. Fewer host trees in the stand result in less damage. Trees in open stands are usually less defoliated than trees in dense stands.

Tree vigor influences susceptibility to budworm damage. Vigorous trees have more foliage and more carbohydrate root reserves than nonvigorous trees. Nonvigorous trees with less remaining foliage after budworm feeding will have greater growth reduction than generally vigorous trees. Vigorous trees have the ability to produce new foliage.

Stand density and species composition also have an important influence on dispersal mortality of larvae. More larvae fall to the ground, where they die, in open stands because trees are farther apart, airborne dispersal time is longer, and wind speeds are greater.

In mixed species stands, more spring dispersing larvae are likely to encounter a nonhost. Consequently, dense pure host stands are often heavily damaged. Multilayered canopies also provide additional feeding sites for dropping larvae whereas single stored stands offer a direct pathway to the ground.

To reduce stand susceptibility, the most vulnerable trees should be removed during normal silvicultural treatments. Regeneration treatments to favor mixed species composition are favored; shade tolerant species should be discriminated against. Least defoliated trees should be retained during partial cuttings, thereby selecting for resistant genotypes. Even-aged silvicultural systems are preferred over uneven-aged systems. Overstory removal in seed tree and shelterwood systems should be done promptly after regeneration is established. Stand vigor should be maintained by appropriate thinnings. Host trees should be harvested at maturity and diseased or otherwise damaged trees removed. Reducing stand susceptibility to budworm damage and improving timber production goes hand in hand.

Budworm populations are normally held to endemic levels by a complex of natural factors including weather, natural enemies (parasites, predators and pathogens), and the quantity and quality of available food. When favorable weather coincides with highly susceptible stand conditions budworm populations expand rapidly, escaping control by natural enemies. A series of 2-3 years of warm, dry weather in the spring and early summer may set off outbreaks. Natural enemies are apparently unable to suppress incipient outbreaks. If weather remains favorable, epidemics will persist until the budworm induces change in stand conditions and depletes its food supply.

As a stand matures foliage biomass per acre expands, and vigor begins to decline. Both quantity and quality of budworm food tends to improve as stands grow older. Female budworm moths are known to prefer mature trees with large crowns for egg laying especially if foliage is exposed to the sun. Both feeding larvae and the egg-depositing moth view mature stands as better habitat than young stands. Since crown exposure of dominant trees is usually greater in uneven-aged stands than in even-aged, the attraction to sunlit foliage for egg laying is a factor of susceptibility.

There is nothing that prevents simultaneous implementation of all silvicultural strategies with the degree of emphasis shifting among them according to the rise and fall of budworm epidemics. Prioritizing harvests is reasonable in the face of an ongoing epidemic. Habitat management to prevent large scale, destructive outbreaks is good forest management. Coupled with the use of insecticides for selected resource protection, silvicultural strategies are the basis for truly integrated pest management.

OTHER INSECT AND DISEASE PESTS

The addressing of these two major insects does not imply that they are the only ones which will, from time to time, affect management decisions on the Gallatin NF. Others will undoubtedly develop in the future on parts of the Forest. Those problems will have to be addressed in specific project designs written for that purpose.

DOUGLAS-FIR BEETLE IN DOUGLAS-FIR

Generalized Site Characteristics and Damage

Like spruce beetle, the Douglas-fir beetle prefers windthrow logging slash, fire-scorched trees, trees damaged by ice or snow. When this material is no longer available following a population buildup, beetles will attack vigorous green trees. Usually, an infestation in healthy trees lasts only 3 to 5 years.

In drier portions of the Rocky Mountains, beetles attacking standing trees prefer those weakened by drought or defoliation over fully vigorous trees. Western spruce budworm or Douglas-fir tussock moth often top kill Douglas-fir and predispose them to beetle attack. There is also an apparent correlation between root diseases and beetle-caused mortality in old growth Douglas-fir. The beetle's success in killing trees is greatest during warm, dry summers. At such times, low vigor, moisture-stressed trees are more likely to succumb than vigorous trees on better sites.

The beetle will produce about three times the brood in windthrow or logs as in standing trees, particularly if windthrow is shaded. As populations increase in logging debris or windthrow, a few beetles attack susceptible living host trees, setting up a strong secondary attraction which, in time, attracts more beetles to the area. If weather conditions are favorable, mass attack of initially infested logs or trees occurs. Though attack density is usually higher in living trees, more brood is produced in slash. When the host material becomes saturated with beetles, the population spills into nearby green trees, and an outbreak develops. That behavorial mechanism which induces mass attacks is responsible for the beetles' ability to attack and kill living trees. Sparse beetle population can be maintained in dead or dying host material. Small numbers of beetles attacking a green tree, however, are usually pitched out.

Hazard Rating Stands

A comprehensive hazard-rating system is being developed for Douglas-fir stands. Presently, stand susceptibility classifications are based on characteristics associated with past outbreaks. According to Furniss et al. (1979), stand susceptibility to Douglas-fir beetle is positively correlated with the proportion of Douglas-fir in the stand, its density, and age. Outbreaks are more prone to develop in pure stands with a basal area greater than 238 sq. ft/ac., codominant trees larger than 13 inches d.b.h., and more than 100 years old. Infestations are usually more intense on north and east aspects followed by west, with south aspects being infested the least. In areas suveyed, frequency of infestations were greater at midslope with frequency decreasing on ridgetops, followed by ravines, and less frequent on benches or flat ground. Mortality was greatest in PSME/PHMA habitat types, then decreasing in the following habitat types--PSME/CAGE, PSME/ACGL, PSME/CARU, PSME/SYAL. Tree killing increased with slope steepness with more mortality occurring in stands on slopes greater than 26 degrees.

While any of these factors can limit amount of damage, high stand density may result in younger trees being attacked. Stand resistance to population expansion increases as (1) susceptible trees are killed or logged, or (2) environmental conditions improve, promoting tree growth. As beetle populations decline, the influence of natural enemies and tree resistance becomes more apparent in maintaining beetle populations at endemic status.

Management Alternatives

Preventive management is the most effective and economical method of reducing damage. Most outbreaks can be prevented by (1) thinning young stands and maintaining desirable spacing until harvest, and (2) removing windthrown, snow broken, or root disease-infected trees.

Other measures that might be considered are:

1. Preventive:

    a. Stands should be hazard rated, with logging priority given to overmature, dense, decadent stands.

    b. Prompt removal of infested trees resulting from windthrow, wind breakage, top killed by defoliators, or fire damage.

    c. Removal of infested logs prior to beetle emergence, i.e., before the spring following attack.

    d. Minimize slash and cull buildup of materials larger than 8 inches d.b.h.

e. Tree length logging is desirable where practical.

f. Trees with root damage, or infected with root disease should be inspected for beetle attack. If infested, remove before beetle emergence.

g. Avoid mechanical damage to residual trees.

2. Remedial: Occasionally infestations develop in standing trees despite precautions. Recommendations listed under "Preventive Measures" should be continued or intensified. Maintain emphasis on high hazard Douglas-fir stands where mortality may be highest, i.e., oldest and largest trees in more dense pure stands.

SPRUCE BEETLE IN ENGELMANN SPRUCE

Generalized Site Characteristics and Damage

All known epidemics of spruce beetle originated from stand disturbances. Areas experiencing widely scattered windthrow are especially conducive to increases in beetle populations. Logging operations resulting in slash accumulations, high stumps, or decked logs have also been known to initiate population buildups. Where large stands of mature spruce are harvested in successive years, spruce beetle problems are more likely to occur. With proper management, outbreaks may be prevented.

The spruce beetle prefers downed material to standing trees. The size of a downed tree is less important than the exposure of its bark to sunlight or contact of the bark with the ground--both of which reduce susceptibility. If suitable downed material is unavailable, standing trees may be attacked.

Large standing trees (greater than 16 inches d.b.h.) are preferred to small trees (smaller than 12 inches d.b.h.). The most preferred are those relatively free of live branches on the basal section. These are found growing in a competitive stand where natural pruning occurs. Open growing trees without competition and with live limbs in the basal portion are less susceptible (Schmid and Beckwith 1975).

Hazard Rating Stands

Spruce susceptibility can be rated more easily and precisely on a stand basis than for individual trees. Knight et al. (1956) outlined the order of susceptibility (in order of decreasing hazard):

1. Stands of large diameter trees along creek bottoms (highest hazard).

2. Better stands on benches and in high basins.

3. Poorer stands on benches and high ridges.

4. Mixture of spruce with other species.

5. Stands of immature spruce.

Unmanaged stands can be rated by using the average diameter of spruce, basal area, species composition, and physiographic locations; three hazard levels are recognized: high, medium, and low (Schmid and Frye 1977). Table 2 illustrates how stands are rated:

Table 2.--Hazard rating for susceptibility to spruce beetle outbreak in Engelmann spruce.

Hazard category	Physiographic location	Average d.b.h. of live spruce > 10" (inches d.b.h.)	Basal area sq ft/ac	Percent spruce in canopy
High	Well drained sites in creek bottoms; site index >120	>16	150+	65+
Medium	Site index 80 to 120	12-16	100-150	50-65
Low	Site index 40 to 80	<12	<100	<50

During infestations, large, old growth trees containing the majority of stand volume are killed. This results in reduced average age of surviving trees, average diameter and height of stand, and spruce component and density. Stand basal area is reduced by 25-40 percent before infestations subside.

Management Alternatives

The use of trap trees is recommended to reduce mortality in managed stands. Trap trees are living merchantable size spruce that are felled, and effectively attract beetles up to one-fourth mile away. Shaded trap trees sustain more attacks than those exposed to the sun. Unbucked trees are more attractive since branches help shade the bole and hold it above the ground. When held off the ground, the undersides of logs attract more beetles than top sides.

The number of trap trees needed depends on the beetle population and the size of trap trees. A trap tree may absorb 10 times the number of beetles a similar standing tree would, so the number of traps will be less than the number of standing infested trees. A ratio of 1:10 (trap trees to standing infested trees) should be used for static infestations, and a ratio of 1:2 to 1:5 depending on beetle populations for increasing infestations. Once infested, they must be removed from the stand before brood adults emerge, which occurs 2 years later. This program can be continued until susceptible stands are logged.

Precautions should be taken to reduce the possibility of a population buildup in logging residue. Some recommended practices are:

1. Cut trees as low to the ground as possible to reduce stump height, preferably less than 1½ feet.

2. Cull logs and tops should be limbed and branches removed from the surface. After limbing, cull logs and tops should be left exposed to full sunlight.

3. Logs and tops should be cut into short lengths--the shorter the better. Complete removal or destruction of all cull logs and tops would eliminate significant host material.

4. If trees are full length logged, the diameter of the small end should be 3 to 4 inches.

5. Where a substantial spruce beetle population exists in adjacent forest, it is better to leave logging residues than to remove or destroy them immediately after cutting. Suitable logging residue will attract emerging beetles and reduce infestation of standing trees. Infested residues must be burned or removed before beetle emergence.

Alexander (1973) suggests several modifications in silvicultural treatments to threatened stands. If spruce beetle populations are present in low numbers in the stand to be cut, or are present in adjacent stands in sufficient numbers to pose a threat, any attacked and all susceptible trees should be removed in the first cut. This will remove most of the larger spruce and is, therefore, a calculated gamble in above average wind risk situations. Subsequently windthrown and attacked trees should be salvaged.

If more than the recommended percentage of basal area to be removed is in susceptible trees, three options are available:

1. Remove all the susceptible trees.

2. Remove the recommended basal area in attacked and susceptible trees and accept the risk of future mortality.

3. Leave the stand uncut.

If the stand is left uncut, probably less than half the residual basal area would be lost and most of the surviving spruce would be of small diameters.

Windthrown trees should be salvaged after they are infested, and before beetles emerge. The exception is where removal encourages further uprooting at the edge of the stand. In some clearcut areas, trees have been windthrown along the edges. Within 1-2 years after having been removed because of the potential beetle threat, further windthrow occurred. Rapid removal prevented the edge trees from developing wind firmness. It might be better to leave windthrown trees, even at the risk of losing a few surrounding trees. An intensive evaluation of the beetle population in the adjacent stand, using the hazard rating system of Schmid and Frye (1977) and the blowdown prediction system of Schmid, 2/ would determine whether to salvage or leave windthrown trees.

Though spruce seedlings need only partial shade, full sunlight causes considerable mortality and logging infested trees may reduce the number of established seedlings below minimum stocking. The spruce component will increase in time because of two factors:

1. Even though true fir seedlings vastly outnumber spruce seedlings, the original removal of the canopy by beetles favors the less shade tolerant spruce more than it does the more shade tolerant fir.

2. Animals damage leaders of fir seedlings more readily than those of spruce; therefore, spruce gains valuable height dominance. In the absence of beetles, spruce lives longer, grows larger, and becomes dominant over fir.

DISEASES AND THE PLANNING PROCESS ON THE GALLATIN NATIONAL FOREST

Diseases with the potential to affect management decisions on the Forest are:

1. Dwarf mistletoe
2. Root disease
3. Others
    a. Stem rusts
    b. Stem decays

2/ Schmid, J. M. 1981. Publication in preparation.

DWARF MISTLETOE

Only one dwarf mistletoe, *Arceuthobium americanum* on lodgepole pine, is present on the Forest. A survey made in 1978 showed 42.0 percent of the lodgepole pine stands to be infected. Growth loss was estimated to be 7.6 cubic feet per acre per year for an annual Forest-wide loss of 502.2 M cubic feet. The major effect of dwarf mistletoe is growth loss, but severe infestations may cause premature tree death.

Stand Susceptibility

Lodgepole pine of all ages and sizes are susceptible. Infestation is directly related to fire and cutting history. If all infected trees in the previous stand were removed by fire or cutting, and if reinvasion from surrounding stands has not occurred, dwarf mistletoe will be absent from the current stand. If any infected trees were left, the current stand will be infested.

Losses are greater on poor sites than on good sites, and greater in dense stands than in released stands. Losses are greatest in dense, old growth stands on poor sites that were infested at an early age.

Management Implications

Dwarf mistletoe causes economic losses to stands managed for timber. Because growth loss occurs annually from infection to harvest, accumulated loss is substantial. Dwarf mistletoe also creates a negative impact on recreation sites by hastening tree mortality. Beneficial effects may occur where stands are managed for range, water production, or big game where tree mortality results in scattered stand openings.

Management Strategies

Dwarf mistletoe losses can be reduced in managed stands through silvicultural treatments. Options include:

1. Regenerating the infected stand using treatments which eliminate the pathogen. Clearcuts are best, but seed tree and shelterwood cuts are suitable if the overwood is removed promptly after regeneration is established.

2. Removing infected overstory trees and thinning/sanitation of the understory. Lightly infected trees are suitable crop trees if they will otherwise release.

3. Changing stand composition to nonsusceptible species.

4. Removing infected residuals from logged or burned stands.

ROOT DISEASE

The major effect of root disease is tree killing, either directly or by predisposing trees to windthrow or bark beetle attack. Mortality may occur as scattered individuals or as centers of dead and dying trees as large as several acres. Timber productivity of areas occupied by large centers is reduced or lost entirely because regeneration usually dies before reaching merchantable size.

Damage from root diseases has not been measured on the Forest, but we believe it to be substantial in local areas.

Stand Susceptibility

Stands of all ages and sizes are affected by root diseases. All conifer species are killed by one or more root diseases in Montana, but frequently one or more species will be somewhat tolerant of the pathogen in any given location.

Management Implications

Root diseases cause mortality of merchantable and unmerchantable trees and growth loss on trees that eventually reach merchantable size. They also take areas out of production as long as susceptible species are regenerated and killed within active centers. In developed recreation sites, they decay root systems and make infected trees hazardous to people and property. Extensive mortality also makes recreation sites less desirable. Openings created by root diseases are occupied by tree regeneration and shrubs, some of which are desirable big game browse. Expanding centers continue adding new areas for browse production.

Management Strategies

Current management recommendations to reduce root disease losses include:

1. Regenerating with site-suited, least affected species. Lodgepole and ponderosa pine are sometimes suitable alternatives to Douglas-fir and subalpine fir.

2. Salvaging dead and dying trees.

3. Reducing projected timber yields. Severely affected stands might be considered for removal from the timber base and allotted to non-timber use. Partial cutting is usually undesirable because it can lead to windthrow, decay behind logging injuries, and increased mortality of residuals.

OTHER DISEASES

Other diseases that may affect management decisions in local areas are stem rusts and stem decays.

Stem rusts reduce wood quality and volume of cankered stems, and may also predispose trees to windthrow.

Stem decays cause defect and cull, especially in old growth stands.

Stand Susceptibility

Lodgepole and ponderosa pine are affected by three stem rusts: *Cronartium comandrae*, *Peridermium stalactiforme*, and *Endocronartium harknessii*. Infection tends to occur in restricted areas, but can be locally heavy and damaging. Site-related factors are unknown.

Fomes pini is a common cause of stem decay in Douglas-fir, Engelmann spruce, and ponderosa and lodgepole pine. Site-related factors are unknown.

Management Implications

Stem rusts cause volume reduction and cull in managed stands. Windthrow may reduce stand density to below desirable stocking levels.

The major effect of stem decays in commercial stands is loss of volume. They also cause hazards in developed recreation sites by predisposing trees to windthrow.

Management Strategies

Stem rust losses can be reduced by removing trees with bole cankers during thinning.

Reducing losses from stem decays is accomplished by removal of defective trees and prevention of damage to leave trees during stand entries.

REFERENCES CITED

Alexander, R. R. Partial cutting in old-growth spruce-fir. USDA-For. Serv., RM-110. 1973. 16 p.

Amman, G. D. Population changes of the mountain pine beetle in relation to elevation. Environ. Entomol. 2: 541-547. 1973

Amman, G. D. Integrated control of the mountain pine beetle in lodgepole pine forests. Proc. XVI IUFRO Congr., Div. II. 1976. pp 439-446.

Amman, G. D. The role of the mountain pine beetle in lodgepole pine ecosystems; impact on succession. In Arthropods in forest ecosystems. W. J. Mattson, ed. 1977. pp 3-18.

Amman, G. D.; McGregor, M. D.; Cahill, D. B.; Klein, W. H. Guidelines for reducing losses of lodgepole pine to the mountain pine beetle in unmanaged stands in the Rocky Mountains. USDA-For. Serv., Intermtn. Forest & Range Expt. Sta., Ogden, UT, Gen. Tech. Rpt. INT-36. 1977. 19 p.

Cole, D. M. Estimating phloem thickness in lodgepole pine. USDA-For. Serv., Res. Pap. INT-148. 1973. 10 p.

Cole, D. M. Feasibility of silviculture practices for reducing losses to the mountain pine beetle in lodgepole pine forests. In Theory and practicing of mountain pine beetle management in lodgepole pine forests. Alan A. Bergman, Gene D. Amman, and Ronald W. Stark (eds.) Symp. Proc., Coll. Forestry, Wildl. Range Sci., Univ. Idaho, Moscow. 1978.

Cole, W. E.; Cahill, D. B. Cutting strategies can reduce probabilities of mountain pine beetle epidemics in lodgepole pine. J. Forestry 74: 294-297. 1976.

Cole, W. E.; Amman, G. D. Mountain pine beetle dynamics in lodgepole pine forests. Part I: Course of an infestation. USDA-For. Serv., Intermtn. Forest & Range Expt. Sta., Ogden, UT., Gen. Tech. Rpt. INT-89. 1980. 56 p.

Evenden, J. C.; Gibson, A. L. A destructive infestation in lodgepole pine stands by the mountain pine beetle. J. For. 38: 271-5. 1940.

Furniss, M. M.; McGregor, M. D., Foiles, M. W.; Partridge, A. D. Chronology and characteristics of a Douglas-fir beetle outbreak in northern Idaho. USDA-For. Serv., Gen. Tech. Rpt. INT-59. 1979. 19 p.

Hamel, D. R.; McGregor, M. D. Harvesting strategies for management of mountain pine beetle infestations in lodgepole pine, Montana. USDA-For. Serv., Northern Region, State and Private Forestry, Missoula, MT. Rpt. 76-3. 1976. 7 p.

Hamel, D. R. Results of harvesting strategies for management of mountain pine beetle infestation in lodgepole pine on the Gallatin National Forest, Montana. In: Alan A. Berryman, Gene D. Amman, and Ronald W. Stark (eds.). Theory and practice of mountain pine beetle management in lodgepole pine forests. Symp. Proc., Coll. Forest., Wildl., and Range Sci., Univ. ID., Moscow. 1978. pp 192-196.

Knight, F. B.; McCambridge, W. F.; Wilford, B. H. Estimating Engelmann spruce beetle infestations in the central Rocky Mountains. USDA-For. Serv., Rocky MT. For. & Range Expt. Stn. Pap. 25. 1956. 12 p.

McGregor, M. D. Management of mountain pine beetle in lodgepole pine stands in the Rocky Mountain area. In Theory and practice of mountain pine beetle management in lodgepole pine forests, Symp. Proc. Dan. A. Berryman, Gene D. Amman, and Ronald W. Stark, (eds.). Coll. For. Wildl., Range Sci., Univ. ID., Moscow. 1978. pp 129-139.

McGregor, M. D.; Amman, G. D.; Cole, W. E. Hazard rating lodgepole pine for susceptibiliey to mountain pine beetle infestation. In: Roy L. Hedden and Janet L. Searcy, (eds.). Hazard rating systems in forest insect pest management; Symposium Proceedings. USDA-For. Serv., Gen. Tech. Rpt. 27, Wash. D.C. 1981. 230 p.

Pfister, R. D.; Kovalckik, B. L.; Arno, S. F. Forest habitat types of Montana. USDA-For. Serv., Intermtn. Forest & Range Expt. Sta., Ogden, UT, Gen. Tech. Rpt. INT-34. 1977. 174 p.

Roe, A. L.; Amman, G. D. The mountain pine beetle in lodgepole pine forests. USDA-For. Serv., Intermtn. Forest & Range Expt. Sta., Ogden, UT, Res. Pap. INT-71. 1970. 23 p.

Schmid, J. M.; Beckwith, R. C. The spruce beetle. USDA-For. Serv. Pest Leaflet 127, 1976. 7 p.

Schmid, J. M.; Frye, R. H. Spruce beetle in the Rockies. USDA-For. Serv. Gen. Tech. Rpt. RM-49. 1977. 38 p.

Stage, A.R. Prognosis model for stand development. USDA-For. Serv. Res. Pap. INT-137. 1973. 32 p.

Tackle, D. A preliminary stand classification for lodgepole pine in the Intermtn. Region. J. Forest. 53: 566-569. 1955.

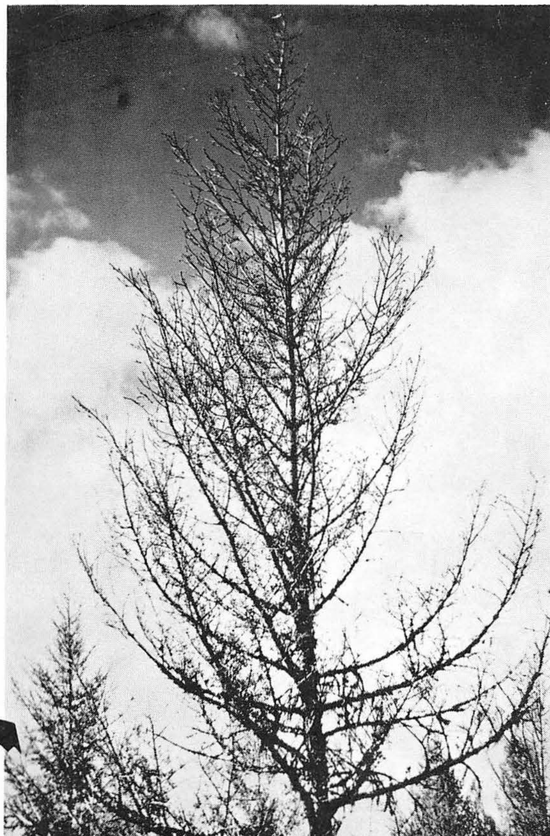
Wilson, G. Timber program review. USDA-For. Serv., Flathead NF, Kalispell, MT. 1979. 3 p.

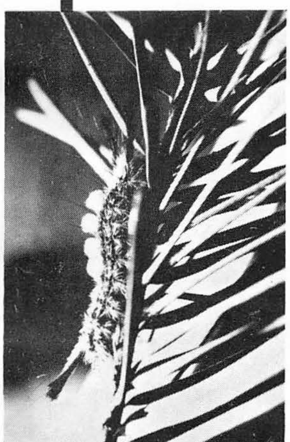
ST

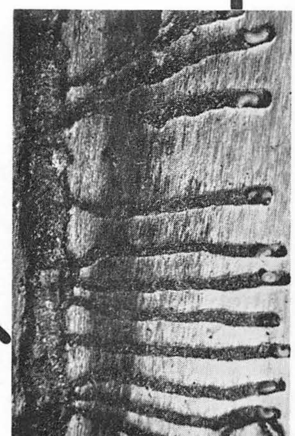
Forest Insect and Disease Conditions

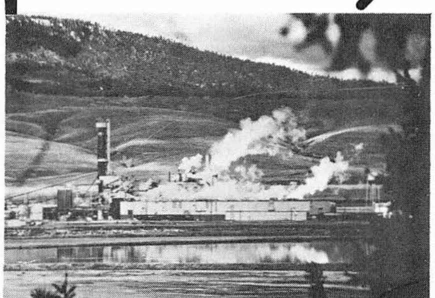
NORTHERN REGION

1973









USDA - FOREST SERVICE NORTHERN REGION
Division of State and Private Forestry

Report No. 74-1

5280

January 1974

R-1 Carto 12/73 TR

Cover photo: Death of the tree in the large photo could have been caused by any one of the factors shown in the small photos, starting at the left and reading counterclockwise: tussock moth larva; air pollution; root rot; Douglas-fir beetle larval gallery.

FORETITLE

STATUS OF FOREST INSECTS

Conditions in Brief

Western spruce budworm damaged approximately 3.5 million acres of Douglas-fir, true fir, and Engelmann spruce in northern Idaho and Montana. Douglas-fir tussock moth defoliated 104,000 acres of mixed Douglas-fir and true fir in northern Idaho and mixed State and private land near Colville, Washington, and 350 acres of Douglas-fir in western Montana. Larch casebearer caused heavy defoliation of larch at lower elevations in northern Idaho, northwestern Montana, and northeastern Washington. Pine butterfly populations declined on the Bitterroot and Lolo National Forests of Montana and Nezperce National Forest, Idaho. Several thousand acres of Douglas-fir were defoliated by the western false hemlock looper near Bigfork and Somers, Montana. The western hemlock looper infestation increased on the St. Joe and Clearwater National Forests, Idaho.

White pine stands continued to sustain heavy losses by mountain pine beetle on the Clearwater National Forest, Idaho, and new outbreaks occurred in white pine stands on the Colville National Forest in eastern Washington. Infestations in lodgepole pine stands continued to increase on the Gallatin National Forest, Montana, and in Yellowstone National Park, Wyoming. Mountain pine beetle continued to deplete second-growth ponderosa pine stands on the Lolo National Forest, Montana. New infestations developed in lodgepole pine stands on the Helena and Lewis and Clark National Forests, Montana. Several thousand ponderosa pine were killed by mountain pine beetle on the Crow Indian Reservation in southeastern Montana.

Douglas-fir beetle infestations declined for the second consecutive year in the North Fork Clearwater River drainage, Idaho, but increased in the South Fork Clearwater River drainage. Pine engraver beetle infestations increased in second-growth ponderosa pine stands along the Clark Fork River drainage in western Montana, and on the Clearwater National Forest, Idaho. A Douglas-fir engraver beetle top killed Douglas-fir along Dworshak Reservoir near Orofino, Idaho. Western pine beetle killed many groups of ponderosa pine on the Nezperce National Forest, Idaho.

Foliar damage was caused by a complex of defoliators on 5,000 acres of lodgepole pine on the Flathead National Forest and in Glacier National Park, Montana. The Bruce spanworm defoliated more than 15,000 acres of quaking aspen in the Turtle Mountains of North Dakota. A pine sawfly defoliated 10,000 acres of lodgepole and ponderosa pine reproduction in the Kootenai National Forest, Montana. The variable oakleaf caterpillar caused light defoliation of basswood, paper birch, and bur oak in North Dakota. Forest tent caterpillar defoliated hardwood shrubs along stream bottoms in many north Idaho valleys. White pine weevil top killed spruce reproduction throughout the Region. The california tortoise shell butterfly defoliated 1,200 acres of shiny leaf ceanothus near Seeley Lake, Lolo National Forest, Montana, and several hundred acres in the Sundance burn, Idaho Panhandle National Forests.

Major Defoliator Problems

WESTERN SPRUCE BUDWORM, *Choristoneura occidentalis* Free.--Area of western spruce budworm infestation decreased from 4.6 million acres in 1972 to 3.5 million acres in 1973 (fig. 1). Defoliation decreased noticeably on all Forests east of the Continental Divide except on the Lewis and Clark National Forest, Montana, and in Yellowstone National Park, Wyoming (table 1).

Table 1.--Acres of aerially visible western budworm defoliation in Region 1, 1973

Unit	Defoliation (acres)	
	1972	1973
Idaho		
Nezperce NF	1,342,000	1,321,000
Clearwater NF	397,600	414,680
Idaho Panhandle NF's[1/]	66,500	146,000
Montana		
Lolo NF	1,350,000	931,000
Bitterroot NF	321,000	347,000
Flathead NF	188,000	120,090
Flathead Indian Reservation	195,500	119,560
Deerlodge NF	335,000	78,320
Helena NF	385,000	44,680
Yellowstone National Park	46,000	17,280
Beaverhead NF	21,000	14,500
Gallatin NF	15,260	11,400
Lewis and Clark NF	0	350

1/ Previously St. Joe NF.

A new outbreak with light to moderate defoliation was detected on 9,000 acres in Douglas-fir stands along the Madison River, Beaverhead National Forest, Montana. Infestations decreased in intensity on the east half of the Lolo National Forest and on the Flathead Indian Reservation in Montana.

An impact survey conducted on the Flathead Indian Reservation showed that most of the grand fir and alpine fir and 13.8 percent of the Douglas-fir were top killed in the Valley Creek drainage west of Arlee, Montana, during a 5-year infestation period. The survey also showed that a total net growth loss of 19.6 board feet per acre occurred during this 5-year period 1967-72. Significant loss also occurred to Christmas tree production and sales because of budworm defoliation.

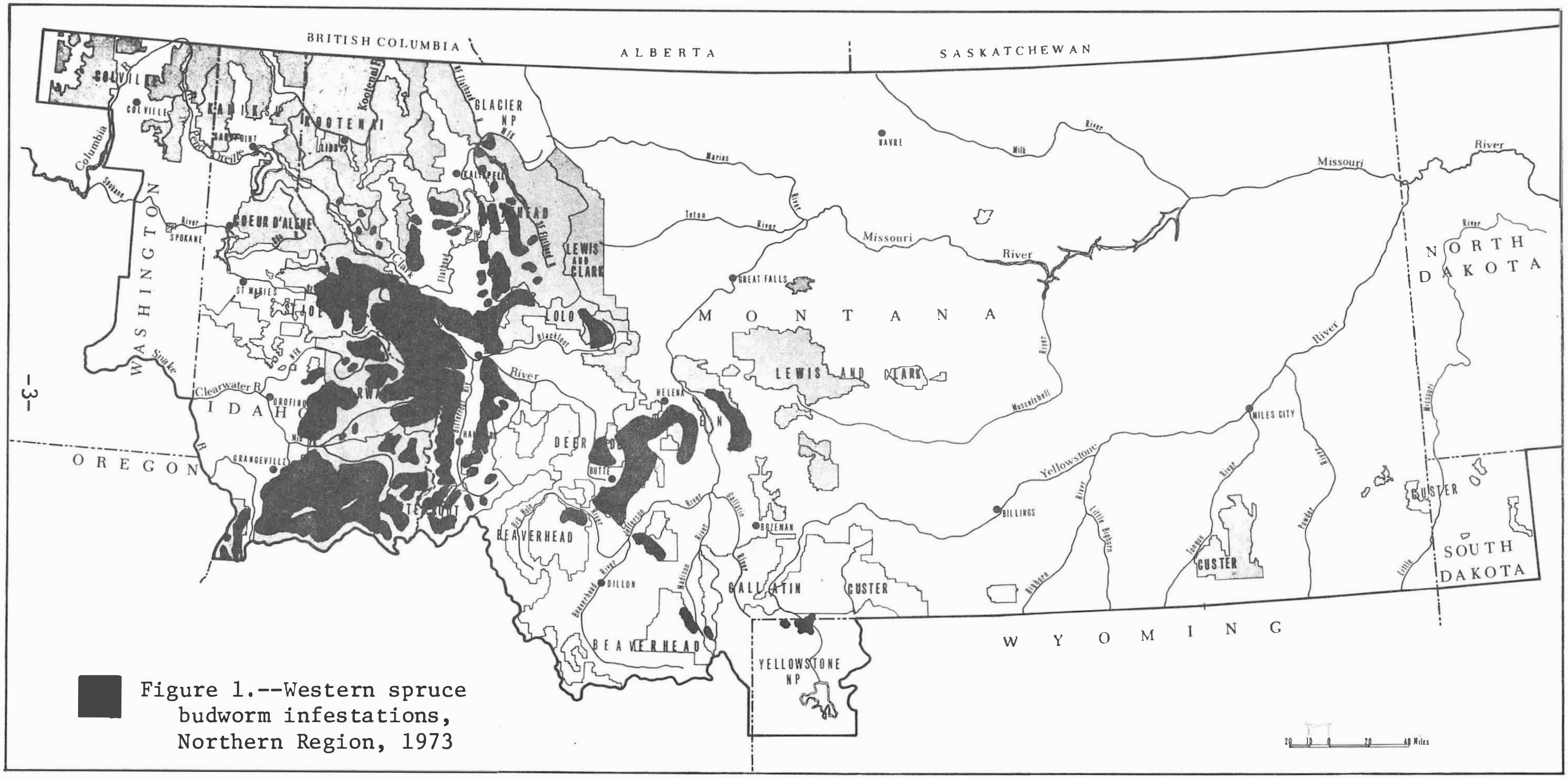


Figure 1.--Western spruce budworm infestations, Northern Region, 1973

Defoliation intensity and acreage infested increased in the Bitterroot National Forest and on the west half of the Lolo National Forest in western Montana. New infestation occurred in scattered patches from Munson Creek to Winniemuck Creek on the Thompson Falls Ranger District, Lolo National Forest, Montana.

Aerially visible defoliation remained at about 1.3 million acres on the Nezperce National Forest, and over 400,000 acres had visible defoliation on the Clearwater National Forest, Idaho. Prolonged feeding for several years has caused extensive top kill and tree mortality on these two Forests and on the Lolo and Flathead National Forests in western Montana. Budworm feeding has affected regeneration programs on these Forests by virtually eliminating the seed source in many areas. Cones have been destroyed by direct feeding and indirectly by the trees being weakened by repeated defoliation to where they fail to produce a cone crop. As a result, the Clearwater, Lolo, and Nezperce National Forests are contemplating establishing seed orchards for affected host species to be closely managed for regeneration purposes. It may be necessary to periodically aerially or ground spray these areas to protect them from budworm damage. A three-stage impact survey is underway to determine growth loss and net impact occurring within infested stands on the Nezperce National Forest.

The greatest increase in acres of defoliation and intensity of damage occurred on the Red Ives Ranger District, Idaho Panhandle National Forests, where the outbreak spread from 86,500 acres in 1972 to 146,000 acres in 1973. Defoliation varied from light to heavy, and considerable top killing is now occurring in this area.

Severe damage is expected in western portions of the Region in 1974. Intensity of defoliation and acreage infested may increase in some east side Forests also.

DOUGLAS-FIR TUSSOCK MOTH, *Orgyia pseudotsugata* McD.--The Douglas-fir tussock moth outbreak mushroomed from small localized infestations to approximately 104,550 acres in Idaho in 1973 (fig. 2). The largest concentrated area of defoliation was 70,000 acres in mixed Douglas-fir grand fir stands on State and private lands and on the Palouse Ranger District, Idaho Panhandle National Forests. In this area, many trees were partially denuded in 1 year of heavy feeding (fig. 3).

In June 1973, the State of Idaho Department of Public Lands, Union Carbide Corporation, and the U.S. Forest Service conducted a pilot test of Sevin-4-oil (Carbaryl) to control Douglas-fir tussock moth populations. The insecticide was sprayed by helicopter at the rate of 1 pound per acre in one-half gallon of No. 2 diesel oil on three 60-acre plots in Benewah and Latah Counties, Idaho. Results showed an average of 70 percent population reduction. Significant amounts

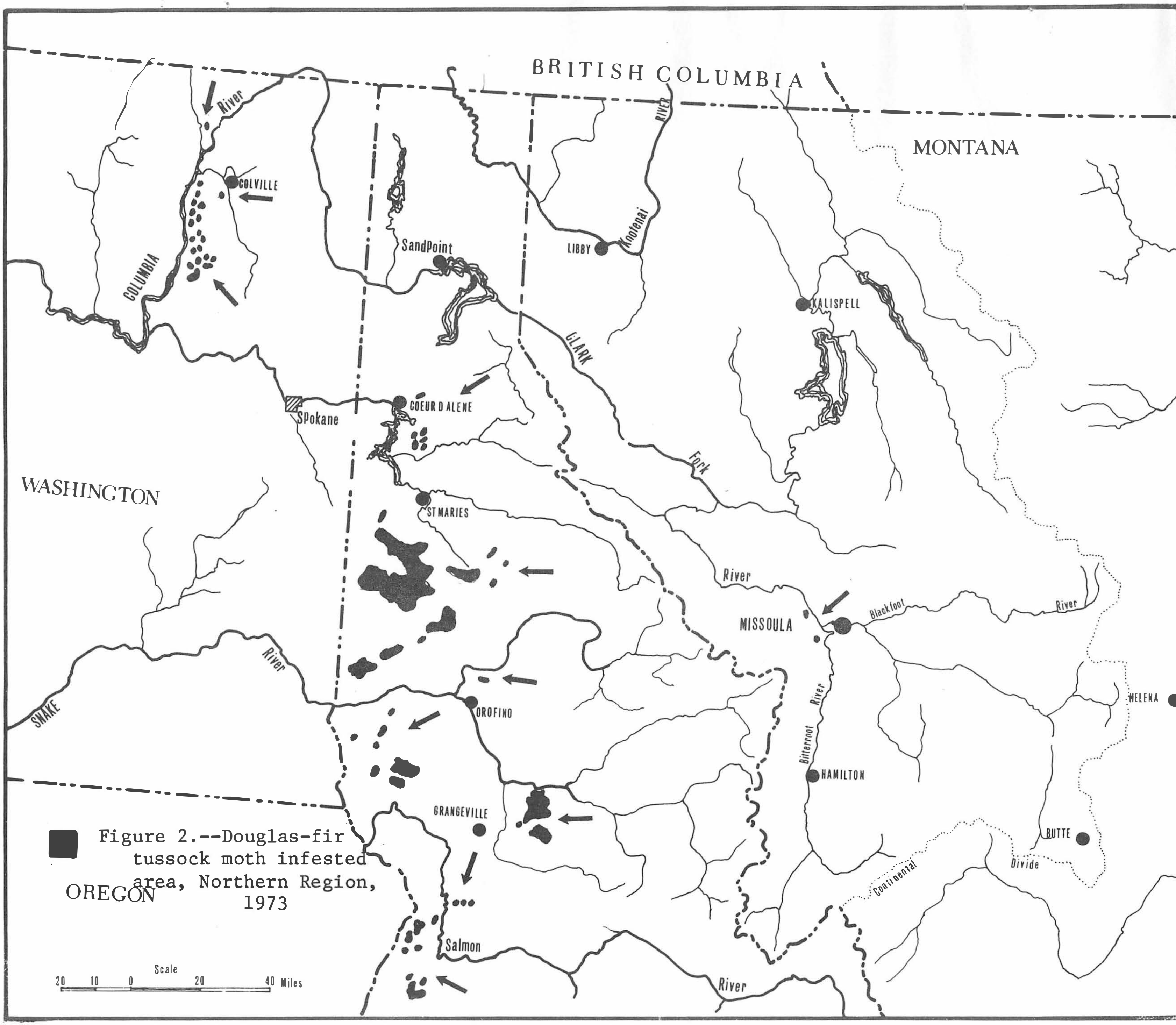


Figure 2.--Douglas-fir tussock moth infested area, Northern Region, 1973

of foliage were saved when sprayed blocks were compared to untreated check blocks. Tussock moth populations in these plots were relatively low (50 to 80 insects per 1,000 square inches of foliage) in comparison to populations reported in other infestations.

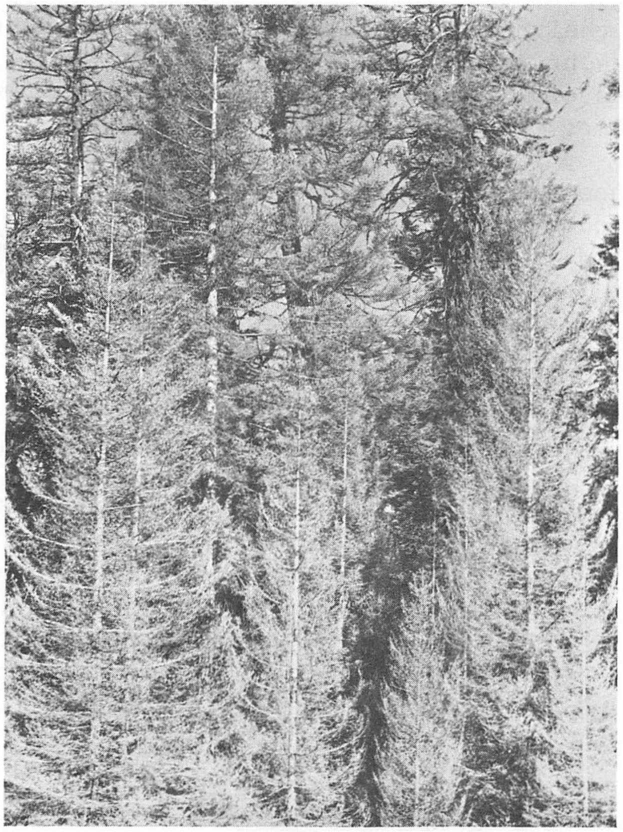


Figure 3.--Stand defoliated by Douglas-fir tussock moth, 1973.

Defoliation of 23,000 acres of mixed Douglas-fir, grand fir occurred in the Selway and Salmon River Ranger Districts on the Nezperce National Forest, Idaho. Localized Douglas-fir stands suffered heavy defoliation on the Salmon River Ranger District near Riggins, Idaho, in 1973.

Aerially visible defoliation of 5,200 acres occurred on private lands along the Columbia River in northeastern Washington. Defoliation varied from light to moderate throughout this infested area.

Four thousand acres of mixed Douglas-fir, true fir stands received moderate to severe defoliation on State, private, and Forest Service lands in the Craig Mountains south of Lewiston, Idaho. One area of 5 acres was heavily defoliated near Johnson's Mill on the Clearwater National Forest in Idaho.

Two small areas of mixed reproduction and pole size Douglas-fir (50 acres in Worden Creek, 300 acres near Frenchtown, Montana) were heavily defoliated in 1973. Complete defoliation occurred on some trees, and some heavily damaged trees may not recover. Surveys conducted in these two areas during late fall 1973 found sufficient egg masses to cause heavy defoliation in 1974. However, these infestations are not expected to spread significantly from their present areas as few new egg masses were detected outside the present infested perimeter. Other spot infestations may appear in western Montana in 1974, but these cannot be detected at the present time.

Surveys conducted in Idaho showed a sufficiently high number of egg masses to result in heavy defoliation in many areas in 1974. Significant tree mortality is expected in stands severely defoliated in 1973.

Plans are being developed to pilot test two microbial insecticides, *Bacillus thuringiensis* Ber., and a naturally occurring polyhedrosis virus in 1974.

LARCH CASEBEARER, *Coleophora laricella* (Hbn.).--Larch casebearer damage was heaviest in western larch stands below 3,000 feet elevation where up to 100 percent of the needles were destroyed in some northern Idaho areas. Moderate to heavy foliar damage occurred to larch stands around Flathead Lake, Columbia Falls, and in the Swan Valley in northwestern Montana. An imported parasite, *Chrysocharis laricinellae* (Ratz.), was released to establish this parasite as a biological control agent in selected larch stands near Moscow, Idaho, and near Evaro, Montana (fig. 4). Release sites will be evaluated in 1974 to determine if this parasite did become established.

Figure 4.--Release of *Chrysocharis laricinellae* to control larch casebearer.

PINE BUTTERFLY, *Neophasia menapia* F. and F.--Infestations on the Bitterroot and Lolo National Forests in western Montana and the Nezperce National Forest in Idaho declined by the end of 1973. Egg and larval predation by pentatomids, poor egg viability, pupal parasitism, and starvation due to depletion of needles by heavy larval populations were significant factors responsible for the population decline. The most significant parasites responsible for population decline are an ichneumonid, *Theronia atlantae fulvescens* (Cr.), and a sarcophagid, *Agria housei* Shewell. The chemical Zectran and the biological agent *Bacillus thuringiensis* Ber. (*B.t.*) were field tested against the pine butterfly in 1973. Two concentrations of each material (Zectran 0.15 pound per gallon per acre and 0.30 pound per gallon per acre; *B.t.* one-half pound per 2 gallons per acre and 1 pound per 2 gallons per acre were applied by helicopter (fig. 5).

Figure 5.--Helicopter applying Zectran for control of pine butterfly populations, Bitterroot National Forest, Montana, 1973.

Each treatment, except the one-half pound *B.t.*, gave over 90 percent population reduction. Both materials are good candidates for pilot testing. Egg mass surveys indicate light to negligible defoliation is expected in the Bitter Root Valley in 1974.

WESTERN FALSE HEMLOCK LOOPER, *Nepytia freemani* Mun.--This defoliator reached epidemic proportions for the first time since 1964 in the Northern Region. Light defoliation was observed in the upper crown of Douglas-fir trees on about 3,500 acres around the north end of Flathead Lake near Bigfork and Somers, Montana. Some tachinids (*Cermoasia auricaudata* Tns.) and ichneumonids (*Phobocampe* sp. and *Apechthis* sp.) were observed parasitizing larval and pupal populations in August 1973.

WESTERN HEMLOCK LOOPER, *Lambdina fiscellaria lugubrosa* Hulst.--Infestations declined in areas defoliated in 1972, but 11,200 acres of mountain hemlock received light defoliation on the Canyon Ranger District, Clearwater National Forest, in 1973. Larvae were common throughout much of the Douglas-fir tussock moth infested stands in Latah and Benewah Counties, Idaho. Infestations are expected to remain at about the same level or decline in 1974.

A PINE SAWFLY, *Neodiprion nanulus contortae* Ross.--Larval populations of this sawfly caused moderate to heavy defoliation of lodgepole pine and ponderosa pine reproduction on 10,000 acres of Kootenai National Forest and private land, West Fork Fisher River drainage, Montana. Heaviest damage occurred in naturally seeded areas on trees 20 feet or less in height. Egg surveys conducted in October indicate a population decline in 1974.

DEFOLIATOR COMPLEX.--A needle miner, *Ocnerostoma strobivorum* Freeman; the pine needle sheath miner, *Zelleria haimbachi* Busck.; and the sugar pine tortrix, *Choristoneura lambertiana* (Busck.), caused defoliation of lodgepole pine on 5,000 acres in an area from Teakettle Mountain on the Glacier View Ranger District, Flathead National Forest, to McDonald Lake in Glacier National Park, Montana. Two-year and older needles were mined by the needle miner, while the pine needle sheath miner and sugar pine tortrix defoliated new growth. A study was conducted in the Teakettle Mountain-Glacier National Park area to determine impact of these insects and fluoride emitted from nearby aluminum reduction plant on lodgepole pine stands. Populations of the pine needle sheath miner and the needle miner were significantly correlated with degree of fluoride found in the air and in needle tissue, suggesting fluorides have predisposed lodgepole pine to attack by these insects.

BRUCE SPANWORM, *Operophtera bruceata* (Hulst).--More than 15,650 acres of quaking aspen in the Turtle Mountains of North Dakota were defoliated by this insect during the spring of 1973.

Major Bark Beetle Problems

Mountain pine beetle, *Dendroctonus ponderosae* Hopk.--The number of western white, lodgepole, and ponderosa pines killed by the mountain pine beetle in 1973 increased over 1972 (figs. 6 and 7). Most white pine mortality occurred on private and State of Idaho lands in the North Fork Clearwater River drainage.

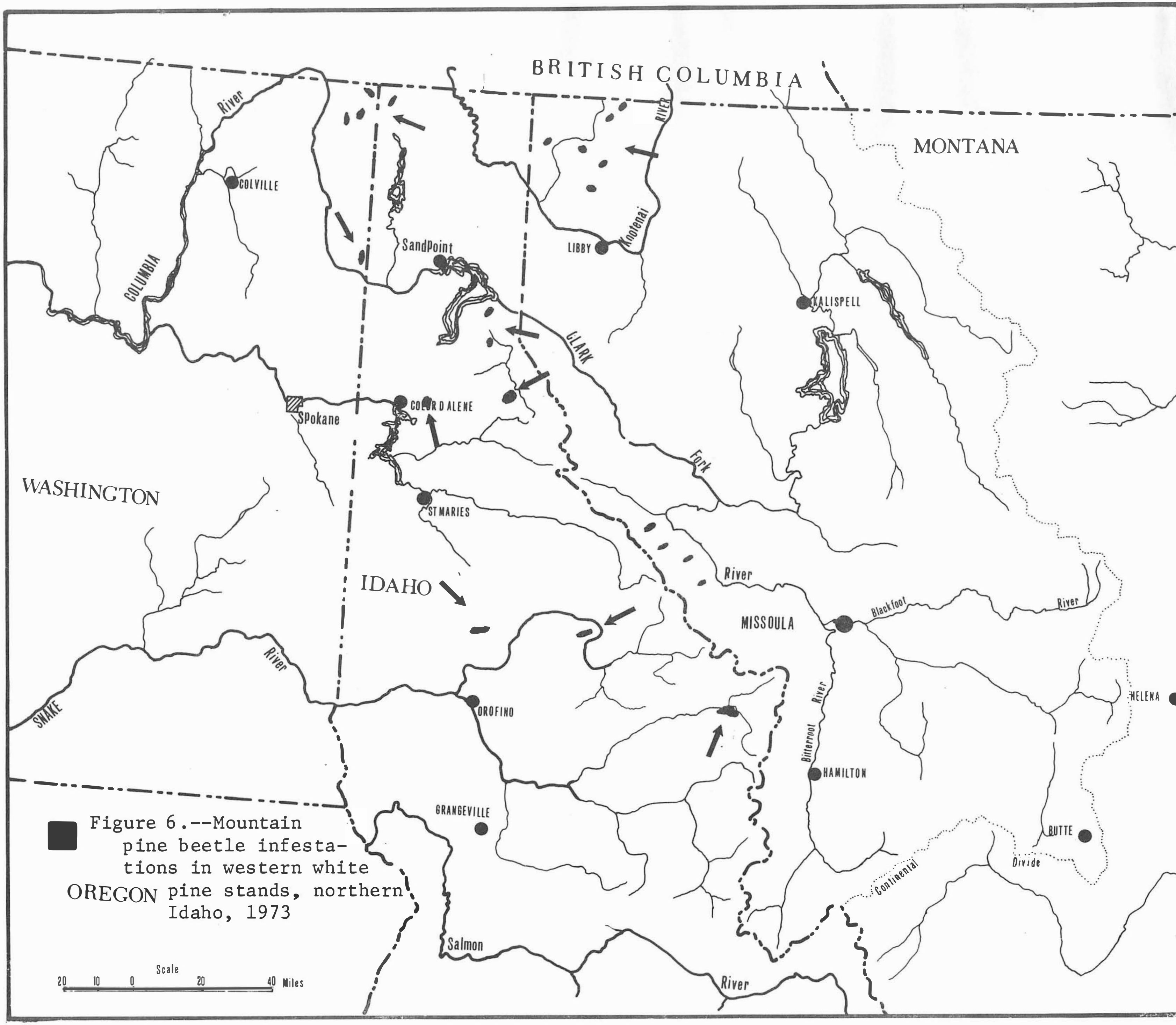


Figure 6.--Mountain pine beetle infestations in western white pine stands, northern Idaho, 1973

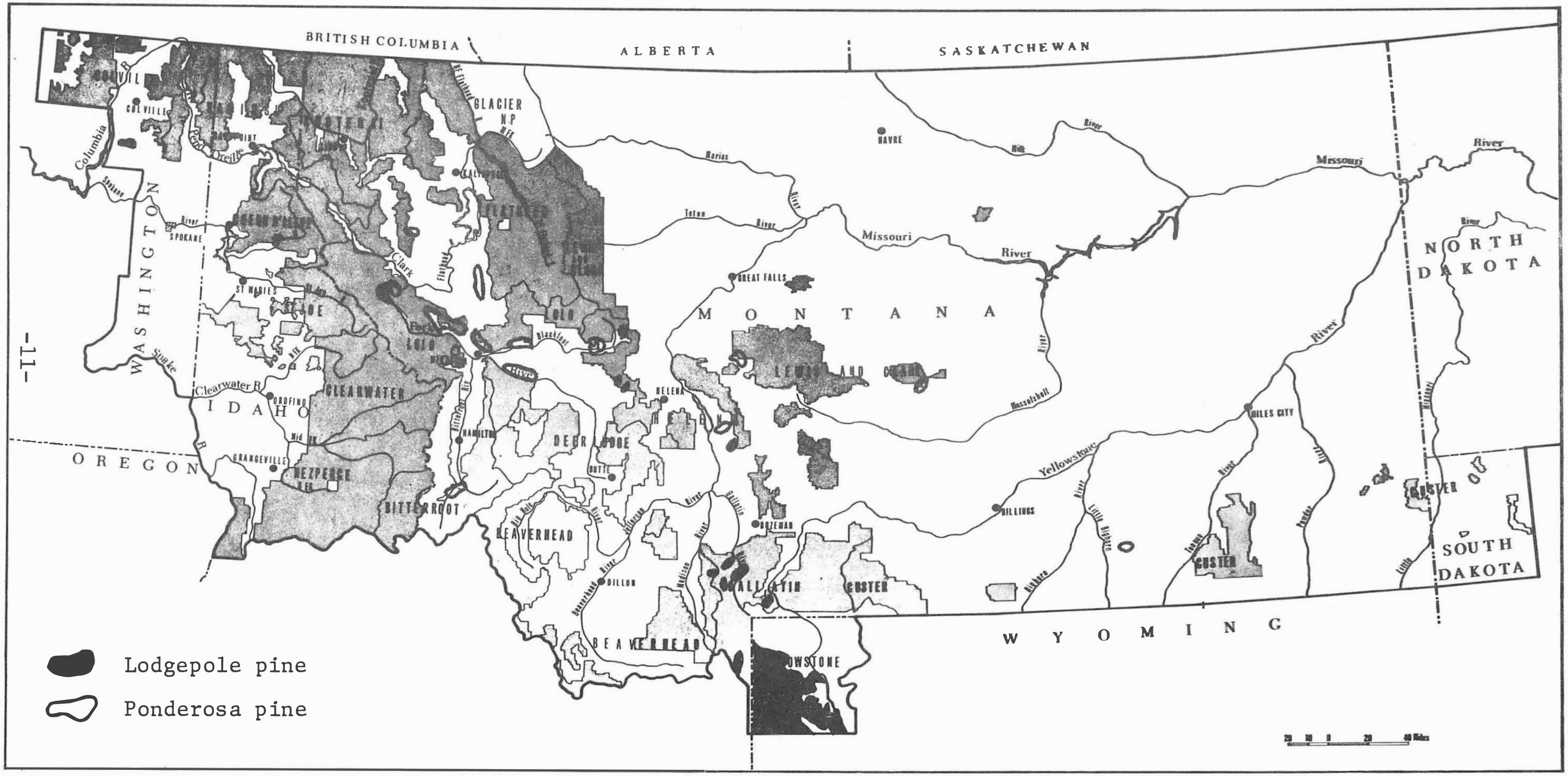


Figure 7.--Mountain pine beetle infestations in lodgepole and ponderosa pine stands, Montana, 1973.

Forest inventory plots established by Potlatch Forests, Inc., personnel in Idaho, in the Pierce-Headquarters area, show the trend is declining and gave an insect-caused net board foot mortality of 2.04 percent per year from 1967-73. This was 77 percent of the total pine mortality; the remainder was due to disease and other factors on private ownership in the North Fork Clearwater River drainage.

Active infestations occurred in Yellow Dog and Downey Creek drainages of the Coeur d'Alene River. New infestations appeared in the Sullivan Creek drainage east of Sullivan Lake in the Idaho Panhandle National Forests. Chronic infestations continue in stands infected with white pine blister rust (*Cronartium ribicola* Fisch.) in north Idaho.

Mountain pine beetle populations expanded in second-growth ponderosa pine stands in the Ninemile drainage, Lolo National Forest, Montana. Surveys of these stands show a decrease in number of infested trees in 1973.

Commercial thinnings of approximately 1,200 acres of second-growth infested stands are in progress on the Ninemile Ranger District to determine the feasibility of this stand management practice for preventing mountain pine beetle attack. One 15-acre block (fig. 8) thinned in 1970 has been free of mountain pine beetle infestation since thinning. Adjacent unthinned stands have a current infestation level ranging from 0 to 23 trees per acre. The outbreak is expected to continue at epidemic level in 1974.

New outbreaks developed to epidemic levels in 60- to 80-year-old second-growth ponderosa pine stands along the Clark Fork River on Bureau of Land Management, National Forest, and private lands between Lyon Gulch and Turah, Montana, in 1973. Many trees within these stands were killed by *Ips pini* Say and *Ips plastographus* (Lec.). Several hundred pine were also killed in the Blackfoot River drainage east of Missoula, Montana, and also in second-growth ponderosa pine stands between St. Ignatius and Flathead Lake on the Flathead Indian Reservation in western Montana.

Epidemic infestations occur in mixed ponderosa pine, Douglas-fir stands in Corral, Thompson, and Cache Creek drainages on the Crow Indian Reservation in southeastern Montana. Surveys of 162 infested acres during fall 1973 show 3,175 trees are infested containing 280,000 board feet. Average buildup of old to newly attacked trees was 1:4 from 1972 to 1973. Only scattered infested tree groups occur in the Cache and Little Corral Creek drainages. Salvage sales are planned to reduce number of infested trees prior to beetle flight in 1974.

Mountain pine beetle reached near epidemic levels in lodgepole pine stands in the Sulphur Creek-Black Butte area in the Big Belt Mountains, Townsend Ranger District, Helena National Forest, Montana. Evaluations show infestations in these areas are static with a decreasing trend.

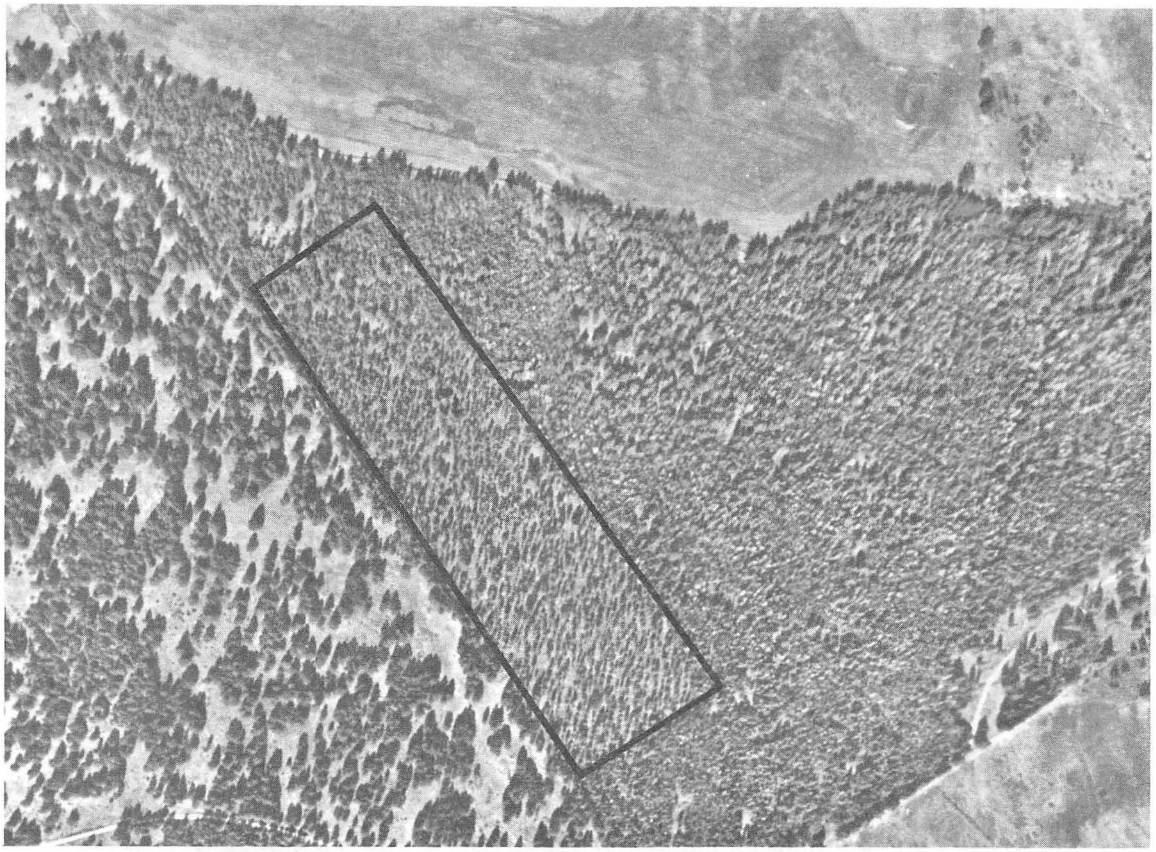


Figure 8.--Fifteen-acre block thinned as a silvicultural control for mountain pine beetle in second-growth ponderosa pine stands, Ninemile Ranger District, Lolo National Forest, Montana. Note abundance of light-colored crowns (red tops) in adjacent outlined portion.

Woodpeckers stripped many trees of bark directly killing bark beetle broods and exposing others to adverse weather factors, contributing to the population decline in the Sulphur Creek drainage. However, many trees in the Sulphur Creek drainage remain susceptible since they have been girdled by porcupines and attacked by *Ips* sp. and *Pityogenes* sp. Many trees partially attacked by these bark beetles are being attacked by mountain pine beetle. Other infestations occur in second-growth ponderosa pine stands on mixed State, private, and Federal lands near Marysville, Unionville, and Lump Gulch near Helena, Montana. Scattered groups of second-growth ponderosa pine were killed by mountain pine beetle and pine engraver beetle, *Ips pini* and *Ips plastographus* on State, private, and Bureau of Land Management lands in the North Fork of Roy and Grunett Creek drainages near Canyon Ferry Reservoir east of Helena, Montana. Beetle populations in these drainages appeared to have built up in blowdown that occurred during winter 1972-73. Newly attacked trees were on dry, rocky sites. With the drought experienced in 1973,

trees were probably stressed and were more susceptible to bark beetle attack. Additional trees stressed by drought in 1973 may be attacked in 1974.

Epidemic conditions persist in lodgepole pine stands in the West Gallatin River drainage, Gallatin National Forest, Montana; Yellowstone National Park, Wyoming; Glacier National Park, Montana; and on the Lincoln Ranger District, Helena National Forest. Surveys are in progress to determine current infestation levels and volume loss in the West Gallatin River infestation.

A new outbreak developed in the Yaak River drainage, Yaak Ranger District, Kootenai National Forest, Montana. An epidemic infestation occurs in ponderosa pine stands in the West Fork Bitterroot River drainage, Bitterroot National Forest, Montana. Small infested groups of ponderosa pine were detected throughout the Lewis and Clark National Forest, Montana.

DOUGLAS-FIR BEETLE, *Dendroctonus pseudotsugae* Hopk.--Ground surveys and population sampling showed that the massive outbreak in the North Fork Clearwater River drainage near Orofino, Idaho, declined sharply in 1973, with an estimated 4,202,110 board foot volume being killed. Infested tree groups were significantly smaller than occurred in 1971 and 1972. The decline is expected to continue in 1974. New infestations developed along the St. Joe River in the Idaho Panhandle National Forests and in Fish Creek drainage, Middle Fork of Clear Creek, and in major tributaries of the South Fork Clearwater River, Nezperce National Forest, Idaho; also in tributaries of the Clark Fork River east of Missoula, Montana, and in the East Fork Bitterroot River drainage, Bitterroot National Forest, Montana. Beetle activity declined to a low level in trees weakened by winter drying in the Bridger Mountains, Gallatin National Forest, Montana. The extreme dry season experienced in 1973 may weaken trees and precipitate increased beetle activity in 1974.

PINE ENGRAVER BEETLES, *Ips* spp.--Infestations increased in many ponderosa pine forests of the Region, probably because of the severe drought experienced in 1973. New outbreaks developed in the Garnet Mountain Range along the Clark Fork River from Drummond downstream to St. Regis, Montana, and several thousand ponderosa pine were killed on the Flathead Indian Reservation in Montana. Minor beetle activity was observed on the Slate Creek Ranger District, Nezperce National Forest, Idaho. *Ips* spp. associated with mountain pine beetle top killed ponderosa pine in many forests of western Montana. Logging activity promoted *Ips* buildup resulting in mortality in ponderosa pine stands at several localities near Deary, Idaho. Extensive mortality is expected in many forests in 1973.

FIR ENGRAVER BEETLE, *Scolytus ventralis* Lec.--Most severe tree mortality occurred in grand fir stands near Coeur d'Alene Lake and on the Mica, Fernan, and Wallace Ranger Districts, Idaho Panhandle National Forests.

Many fir engraver infestations were associated with root rot centers. Tree killing decreased in grand fir stands on the Clearwater Ranger District, Nezperce National Forest, Idaho. New infestations developed in Douglas-fir adjacent to cutover areas in the Big Belt Mountains, Townsend Ranger District, Helena National Forest, Montana. Infestations are expected to continue at epidemic levels in 1974.

OTHER INSECTS.--A Douglas-fir engraver beetle, *Scolytus tsugae* (Sw.), killed and top killed several hundred Douglas-fir around Dworshak Reservoir near Orofino, Idaho. Lower bole sections of top-killed trees were attacked by Douglas-fir beetle and the California flatheaded borer, *Melanophila drummondi* (Kirby). Extremely dry weather conditions experienced this year may stress trees and result in increased tree killing by *M. drummondi* in 1974. The variable oak leaf caterpillar, *Heterocampa manteo* (Dbldy.), caused light, widely scattered defoliation of paper birch, American basswood, and burr oak in the Killdeer and Turtle Mountains and on the Fort Totten Indian Reservation in North Dakota. The white pine weevil, *Pissodes strobi* Peck, top killed spruce reproduction in open-grown spruce stands throughout the Region. Damage is expected to increase as cutover areas are regenerated with spruce. The California tortoise shell butterfly, *Nymphalis californica* Boisduval, defoliated 1,200 acres of shiny leaf ceanothus near Seeley Lake, Montana, and in the Sundance burn in north Idaho. The forest tent caterpillar, *Malacosoma disstria* Hbn., defoliated birch, hawthorn, and other broadleaf species along river bottoms near Coeur d'Alene and St. Maries, Idaho, and the Jocko River in Montana, and elms in the city of Billings, Montana. The flea beetle, *Altica bimarginata* Say, completely defoliated alder on several hundred acres along the Lochsa River in northern Idaho. Feeding by nymphs and adults of a lacebug, *Corythucna scitula* Drake, caused yellowing of leaves and early leaf drop of alder on the Kelly Creek and Canyon Ranger Districts, Clearwater National Forest, Idaho. The rusty tussock moth, *Orgyia antiqua* (Linn.), defoliated numerous browse species on the Clearwater National Forest, Idaho, and Lolo National Forest, Montana. Cooley spruce gall aphid, *Adelges cooleyi* (Gillette), caused yellowing of needles of reproduction and pole size Douglas-fir throughout much of the Flathead National Forest and in widely scattered areas of the Lolo National Forest, Montana. The spring cankerworm, *Paleacrita vernata* (Peck.), continued to cause noticeable defoliation of Siberian elm shelterbelts in North Dakota. Fall cankerworm, *Alsophila pometaria* Harr., defoliated green ash in the North Dakota badlands.

STATUS OF FOREST DISEASE

Conditions in Brief

Root decay fungi, *Poria weirii* and *Armillaria mellea*, were found causing mortality in young Douglas-fir, ponderosa pine plantations, and *Fomes annosus* was found contributing to mortality in 200- to 300-year-old ponderosa pine stands. Dwarf mistletoe control accomplishments were decreased due to withdrawal of funds. Annual impact of dwarf mistletoes on the Flathead Indian Reservation has been estimated to be $123,750. In general, foliage diseases were spotty in occurrence and locally severe in certain areas. Elytroderma needle blight was probably the most damaging foliage disease. At the Coeur d'Alene nursery significant numbers of dead spruce, grand fir, and Douglas-fir seedlings were colonized by root pathogens. Losses were as high as 30 to 40 percent in some beds.

Noninfectious (abiotic diseases) were prominent during 1973. Approximately 13,500 acres in the Blackfoot Valley of Montana were subject to winter injury. Drought symptoms were noted on several coniferous species, particularly in northern Idaho. Air pollutants were implicated as causing damage to approximately 5,000 acres of Douglas-fir around Missoula, Montana, and to vegetation near Butte, Montana. A significant growth reduction of lodgepole pine caused by an air pollutant-insect complex was measured near Columbia Falls, Montana.

Status of Diseases

ROOT DISEASES.--Remote sensing techniques have been found to be highly reliable in the detection of root disease centers in some stands in the Idaho Panhandle National Forests. As much as 70 percent of some of these stands are visibly affected by root disease (fig. 9).

Utilizing remote sensing techniques, a root disease impact survey is currently being conducted on the Coeur d'Alene National Forest portion of the Idaho Panhandle National Forests. Although a complex of at least seven fungi is apparently involved, the most abundant pathogens seem to be *Poria weirii* (Murr.) Murr. and *Armillaria mellea* (Vahl ex Fr.) Kumm. (fig. 10).

Armillaria mellea and *Fomes annosus* (Fr.) Cke. were found contributing to mortality in 200- to 300-year-old ponderosa pine in the Lone Pine area of the Flathead Indian Reservation. Numerous overmature ponderosa pines have been dying in the area for several years, and in many cases mortality was attributed to western pine beetle, *Dendroctonus brevicomis* (Lec.). Several 1973 faders containing beetles were bulldozed over and roots examined. In one case, advanced decay caused by *Fomes annosus* was found in over 90 percent of the tree's roots. However, in

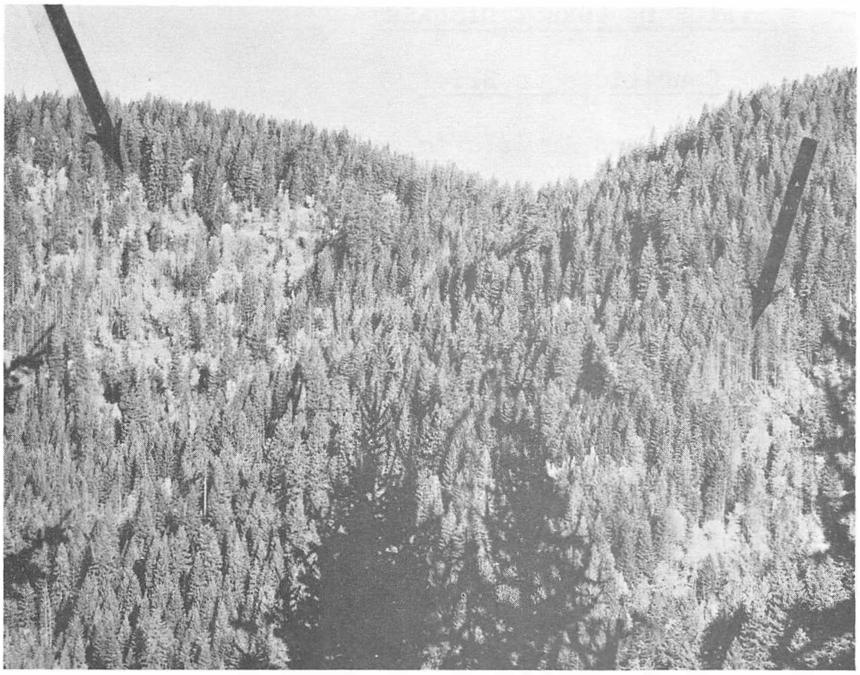


Figure 9.--Root disease centers (light gray) as they appear in the fall when shrubs in centers have turned yellow and red in contrast with the green canopy (dark gray) of unaffected conifers. A complex of fungi involving *Poria weirii* is responsible for the centers.

Figure 10.--Laminated root rot of grand fir. *Poria weirii* alone or in combination with one to six other decay fungi causes this type of damage in northern Idaho.

another case, only minor amounts of *Armillaria mellea* were present (fig. 11).

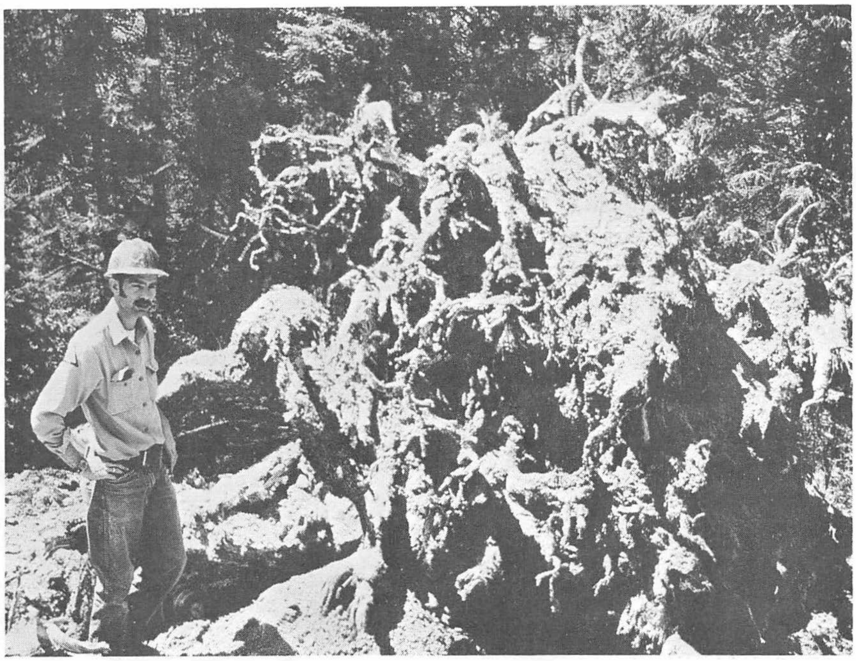


Figure 11.--Mature ponderosa pine with over 95 percent of its roots decayed by *Fomes annosus*. The tree had also been attacked by western pine beetle.

On the Selway Ranger District of the Nezperce National Forest, approximately 3,000 acres of young, mixed composition (primarily Douglas-fir) plantations were inventoried for information including mortality caused by root disease. *Armillaria mellea* was found killing ponderosa pine saplings, while *Poria weirii* was found killing Douglas-fir and grand fir seedlings and saplings. Although survey data are not available at this time, observations indicate that insignificant mortality caused by root pathogens is occurring.

STEM DECAYS.--Isolations made from subalpine fir, Engelmann spruce, and Douglas-fir which had been scarred during a selective logging operation 10 years ago yielded *Stereum sanguinolentum* (Alb. and Schw. ex Fr.) Fr. in nearly all cases. Although only a relatively few wounds were evaluated, these preliminary results indicate that care should be taken to avoid wounding residual trees in selective cutting operations.

DWARF MISTLETOES, *Arceuthobium* spp., were controlled on approximately 4,000 acres. More acreage would have been worked, but some of the allotted funds were withdrawn to combat insect outbreaks in other Regions.

Data from inventory plots in Douglas-fir and western larch stands on the Flathead Indian Reservation show an annual loss to dwarf mistletoes

of $0.63 per acre. Expanding this to the entire reservation gives an annual loss of $123,750.

DUTCH ELM DISEASE, *Ceratocystis ulmi* (Buism.) C. Moreau, was recovered from one American elm in Missoula, Montana. This is the first record of the occurrence of this pathogen in Montana. The fungus was also recovered from Amèrican elm in the Bismarck, Mandan, and Fargo areas of North Dakota.

NEEDLE CASTS.--*Elytroderma deformans* (Weir) Darker was particularly severe on ponderosa pine in the Bitter Root Valley and Flathead Valley of Montana. Much new infection was observed. It was found to be of widespread occurrence primarily on ponderosa pine but also on lodgepole pine in northern Idaho (fig. 12).

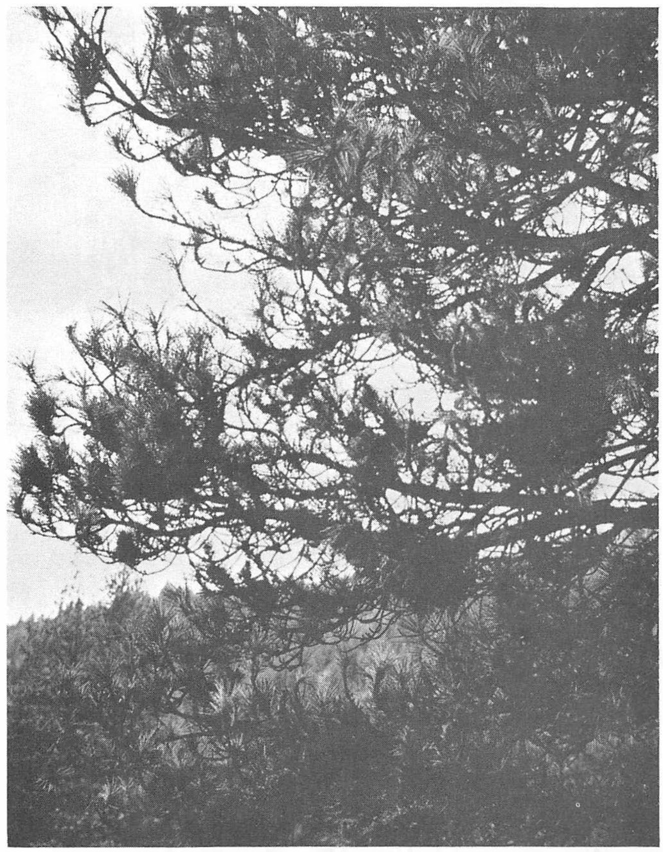


Figure 12.--Defoliation and brooming caused by *Elytroderma deformans* on ponderosa pine.

Lophodermella arcuata (Darker) Darker was of localized occurrence in the Coeur d'Alene River and Hayden Creek drainages of the Idaho Panhandle National Forests.

Lophodermium pinastri (Schrad. ex Fr.) Chev. caused minor defoliation of natural ponderosa pine in isolated areas of the Flathead Indian

Reservation near Arlee, Montana, and in the Hayden Creek area of the Idaho Panhandle National Forests. This fungus, or one very close to it, is causing moderate defoliation of planted ponderosa pine in areas of the Idaho Panhandle National Forests near Bonners Ferry, Idaho, and also in the Hayden Creek area.

Lophodermella concolor (Dearn.) Darker was locally heavy on lodgepole pine in areas of the Colville National Forest east of Colville, Washington, and in the Hellroaring Creek area of the Bitterroot National Forest in Montana.

Rhabdocline pseudotsugae Syd. caused severe defoliation of Douglas-fir in the Lochsa River drainage, but was infrequently found elsewhere.

NEEDLE RUSTS.--Needle rusts, *Pucciniastrum* spp., were found on grand fir in the Beauty Creek, Rutherford Gulch, and Boundary Peak areas of the Idaho Panhandle National Forests (fig. 13). Seedlings and saplings were moderately affected with up to 50 percent of current year's foliage damaged in some cases.

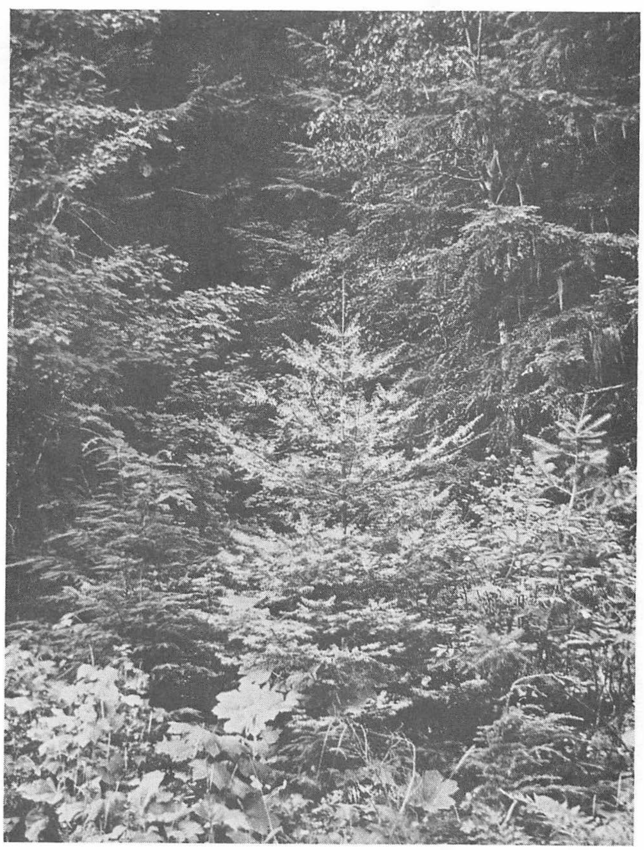


Figure 13.--Needle rust (*Pucciniastrum* sp.) of grand fir. Light gray needles have been killed by the rust organism.

OTHER FOLIAGE DISEASES.--*Lecanosticta* sp. (needle blight of western white pine) caused severe defoliation of western white pine in localized areas of the Priest River and Coeur d'Alene River drainages of the Idaho Panhandle National Forests. In many cases the lower one-third of the crowns of affected trees was completely defoliated, probably due to a combination of suppression and the fungus.

Red band needle blight, caused by *Scirrhia pini* Funk and Park, was of moderate but declining severity in ponderosa pine stands in the Lochsa River and Priest River drainages.

NURSERY DISEASES.--Seedling losses at the Coeur d'Alene nursery were 30 to 40 percent or higher in some nursery beds. Affected were 2-0 Engelmann spruce and 1-0 Douglas-fir and grand fir. Isolations made from dead and dying seedlings yielded a high percentage of two or more *Fusarium* spp. Although known pathogens were found in the affected seedlings, their presence is probably due to improper nursery bed conditions and are probably not the sole cause of mortality.

Winter injury was especially severe on 2-0 spruce in the nursery, but trees generally recovered and grew rapidly during the summer. No correlation between winter injury and incidence of root pathogens was evident (fig. 14).

Figure 14.--Winter and frost damage to 1-0 Douglas-fir in the Coeur d'Alene nursery.

DROUGHT.--Various amounts of abnormal defoliation of western redcedar, grand fir, and ponderosa pine were observed in the Idaho Panhandle National Forests. This defoliation is probably due to the drought conditions which occurred during the winter of 1972-73 and hot, dry conditions which occurred during the summer of 1973. Western redcedar was severely affected in some areas and may result in a minor amount of mortality.

WINTER DAMAGE (RED BELT).--In the Blackfoot Valley of western Montana, aerial surveys supported by ground observations showed that 13,500 acres of ponderosa pine were damaged by cold or dehydration during the winter of 1972-73. Damage on 12,340 acres was classified as light, 800 acres as moderate, and 360 acres as severe. Douglas-fir was not affected. Very light damage to ponderosa pine was noticed in other parts of western Montana, including the Clark Fork Valley east and west of Missoula, the Bitter Root Valley, and the Flathead Valley. Trees are not expected to die (fig. 15).

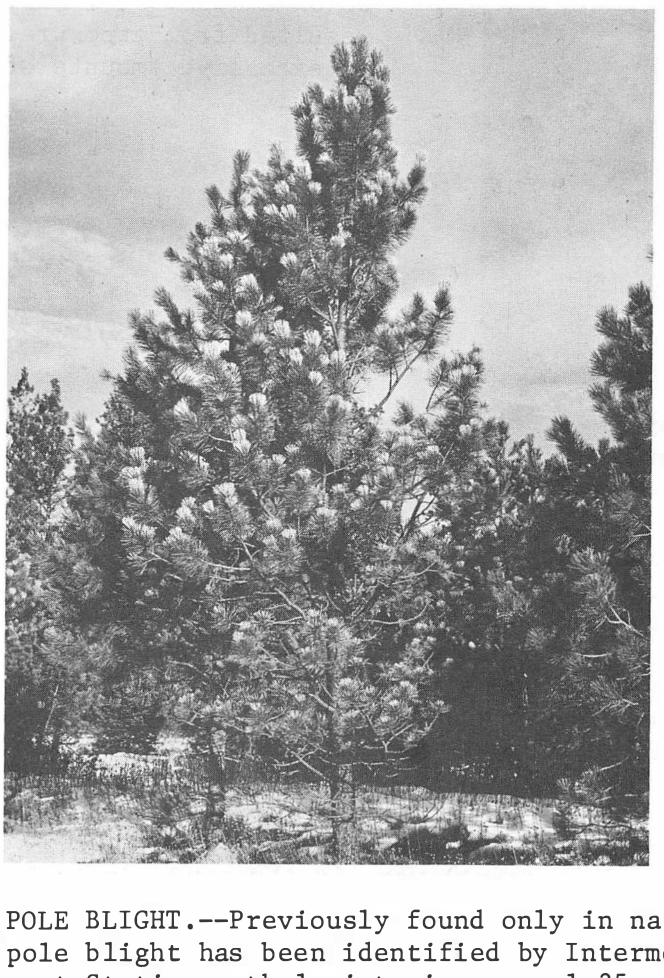


Figure 15.--Winter damage to terminals of ponderosa pine in the Blackfoot Valley.

POLE BLIGHT.--Previously found only in natural western white pine stands, pole blight has been identified by Intermountain Forest and Range Experiment Station pathologists in several 35- to 40-year-old western white pine plantations around Deception Creek on the Idaho Panhandle National Forests.

AIR POLLUTANTS.--A diseased condition of Douglas-fir was noted in February 1973 adjacent to a paper mill which emits large amounts of reduced sulfur and moderate amounts of sulfur dioxide near Missoula, Montana. The 2-year and older foliage had developed partial (tip) to complete necrosis (fig. 16). An aerial survey was made and visible injury was found over 5,000 acres of Federal, State, and private lands.

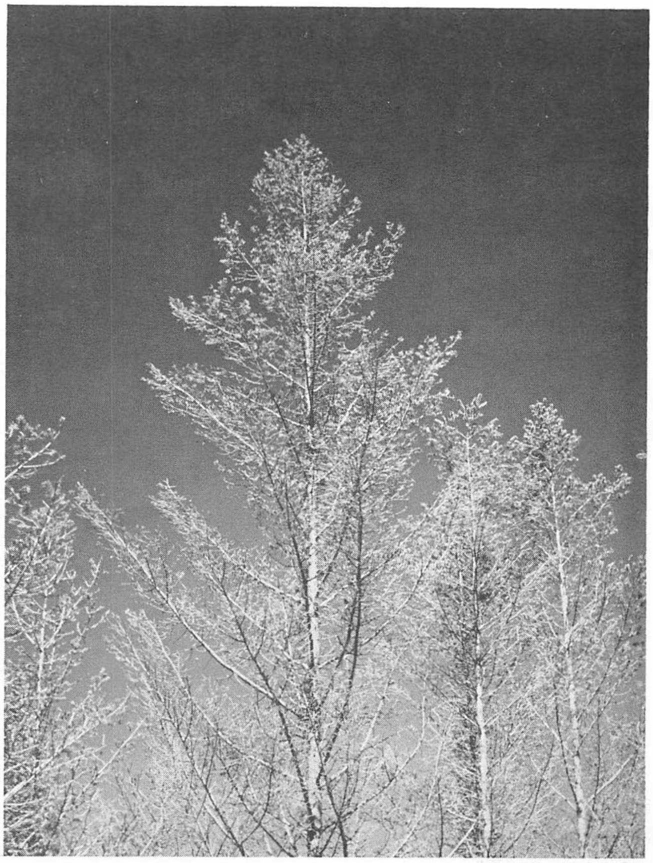


Figure 16.--Moderately defoliated Douglas-fir near Missoula, Montana. Defoliation most likely resulted from exposure to excessive amounts of sulfur.

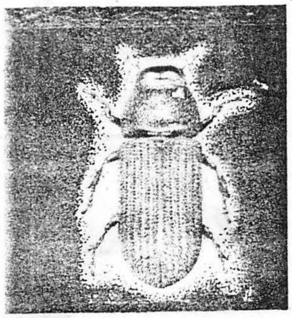
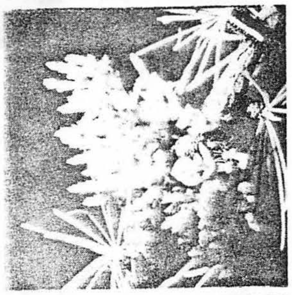
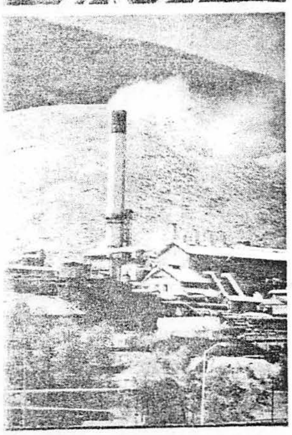
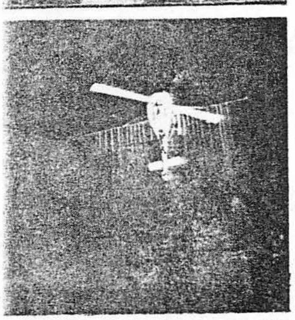
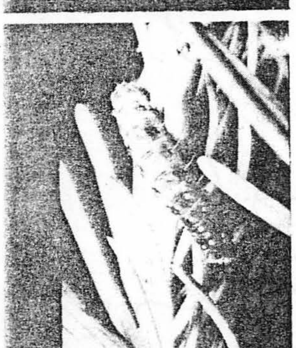
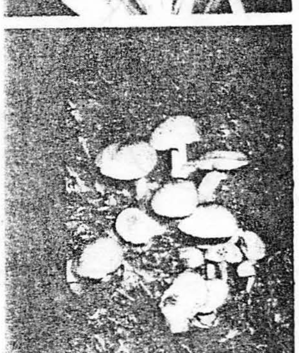
It was concluded that neither insects nor pathogenic fungi were responsible. Winter damage as a cause was also ruled out. Sulfur concentrations in affected tissue reached as high as 30 times that found in needles from control areas. High amounts of total sulfur and considerable sulfur dioxide were found in the air within the affected area. The most probable explanation of cause was determined to be excessive sulfur in the reduced and oxidized forms. Histological analyses of needle tissue supported this conclusion.

An estimated total merchantable volume of 3,108,891 board feet was affected: 672,205 board feet (22 percent) were in the none-to-lightly affected category; 1,779,469 board feet (57 percent) were in the moderate; and 657,217 board feet (21 percent) were in the severe category. Few of the trees were dead. If fumigation continues as is expected, considerable mortality will occur.

Clinical effects of fluorides emitted from the Anaconda aluminum plant at Columbia Falls, Montana, have been documented. Data from Stage II examination of 22 separate stands in the area showed a rather consistent significant reduction in growth attributable to the fluoride-insect complex present in the area. This reduction was independent of site or weather factors. The impact in terms of board foot loss has not yet been calculated.

A chemical plant producing elemental phosphorous near Butte, Montana, emits hydrogen fluoride. Although little fluoride injury was found on vegetation during a detection survey around the facility, the amounts accumulated by plants represent a threat to foraging animals that consume that vegetation.

☆U.S. GOVERNMENT PRINTING OFFICE: 1974—799-636/70

FOREST ENVIRONMENTAL PROTECTION

USDA · FOREST SERVICE · NORTHERN REGION

State & Private Forestry · Missoula, MT 59801

Report 76-13

5200
July 1976

STATUS OF BARK BEETLE POPULATIONS IN WINDTHROW
FLATHEAD NATIONAL FOREST
MONTANA

1976

M.D. McGregor, D.R. Hamel, and R.D. Oakes

ABSTRACT

Windthrow occurred during late April on the Glacier View, Hungry Horse, Spotted Bear, and Swan Lake Ranger Districts, Flathead National Forest. An evaluation to determine potential for development of spruce beetle and Douglas-fir beetle outbreaks was made during late June and early July. All areas examined were classed as having low or medium potential for outbreak development. Salvage logging is recommended to further reduce outbreak potential.

INTRODUCTION

An evaluation was made to determine the potential for bark beetle buildup in blowdown that resulted from strong winds during the last week of April 1976.

Windthrow occurred in Whale Bench, Whale-Moose, Upper Moose, Red-Moose, Hay, Langford, Wolverine, McGinnis East, Depuy-McGinnis, Kimmerly, and Canyon Creek drainages on the Glacier View Ranger District; in Dudley, Lost Johnny Landing, Wildcat, Felix, Aeneas, Forest, and Biglow drainages, Hungry Horse Ranger District; Quintonkin, Ball, Branch, Posey, and Connor drainages, and the Taylor Loop Road, Spotted Bear Ranger District; and Wild Bill, and Dayton-Ronan Sale, Swan Ranger District (Figure 1).

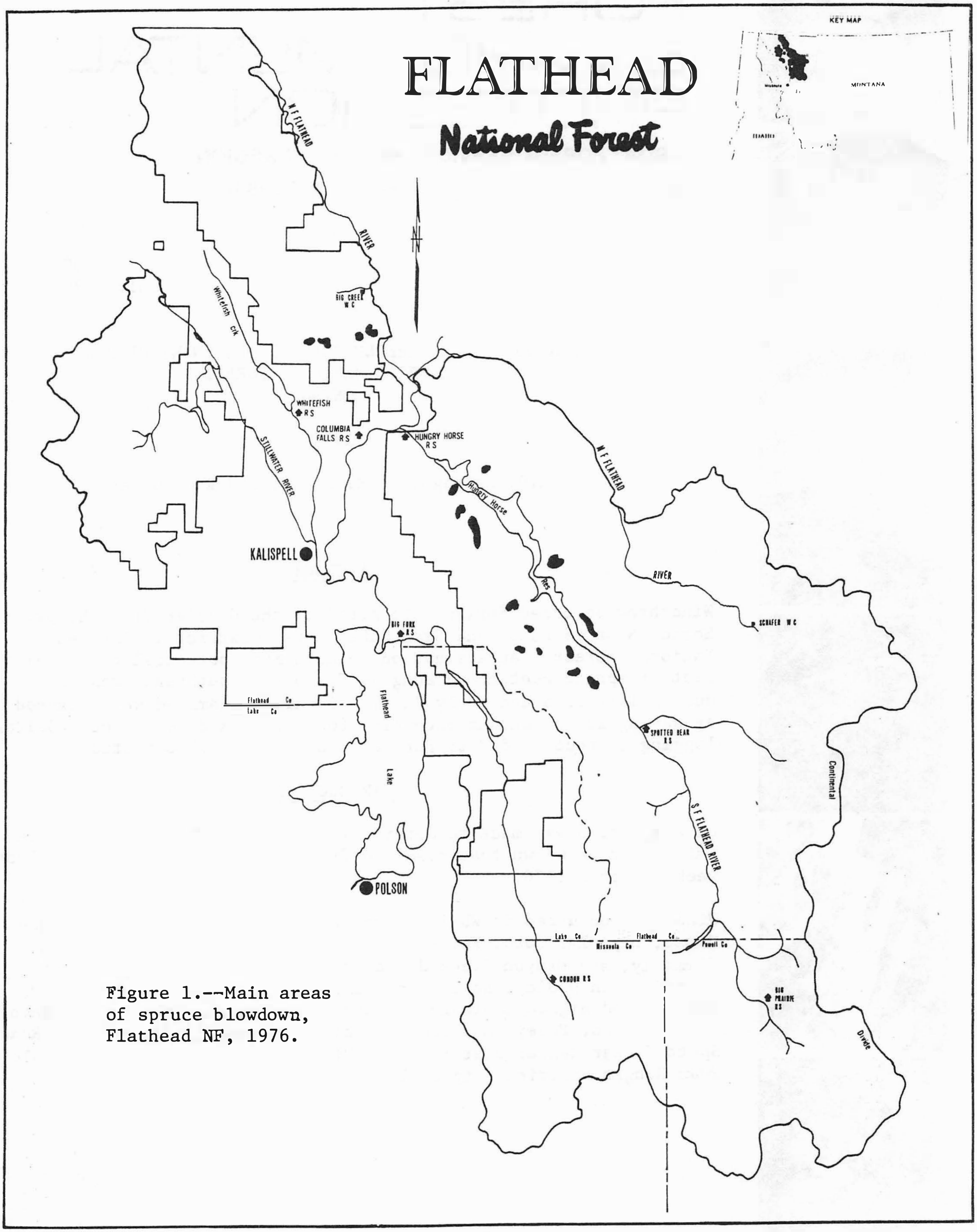


Figure 1.--Main areas of spruce blowdown, Flathead NF, 1976.

and the population can increase rapidly, conceivably as much as ten-fold or more in one generation (Atkins and McMullen 1960). This may also apply to spruce beetle populations as both prefer windthrow, slash, and logging debris over standing trees.

When the preferred host material has been reduced, infestations will manifest themselves in standing trees.

In rating stands adjacent to windthrow for potential to spruce beetle outbreaks, factors such as physiographic location, tree diameter, basal area, and percentage of spruce in the canopy were used.

Schmid and Frye (1975) established the following potential outbreak rating:

Stand risk value	Potential outbreak rating
11-12	High
7-9	Medium
4-5	Low

To calculate the rating the following risk categories for potential spruce beetle outbreaks for each stand characteristics were used:

Risk category	I Site index	II Av. diameter of live spruce above 10 in d.b.h.	III Basal area	IV Proportion spruce in canopy
		In. d.b.h.	$Ft.^2$	Percent
High (3)	Spruce on well-drained sites in creek bottoms	16	150	65
Medium (2)	Spruce on sites with site index of 80-120	12-16	100-150	50-65
Low (1)	Spruce on sites with site index of 40 to 80	12	100	50

Based on data taken, ratings for stands adjacent to windthrow were rated as shown in table 1.

Data shows that most stands were rated with a low potential for a spruce beetle outbreak. Only Canyon Creek, Kimmerly, and Depuy-McGinnis blowdown on the Glacier View District; and Wildcat blowdown on the Hungry Horse District were rated as having medium potential for an outbreak developing.

RECOMMENDATIONS

Based on data collected during evaluation of the blowdown areas, the following is recommended:

1. All areas of concentrated blowdown should be salvage logged within 1 year. This will reduce the potential for standing green trees becoming infested by spruce beetle and Douglas-fir beetle, that may complete a generation in 1 year, fly and infest new host material.

2. Tops should be kept small (under 8 inches in diameter).

3. Concentrated groups of trees with roots intact that cannot be removed this season should be re-examined next year prior to beetle flight to determine potential for outbreak development.

4. Care must be taken that as little mechanical damage as possible occurs to the residual stand. This includes root damage such as that caused by road cuts.

REFERENCES CITED

Atkins, M.D. and L.H. McMullen. 1960. On certain factors influencing Douglas-fir beetle populations. Fifth World Forestry Congress, Seattle, Washington.

Dyar, E.D.A., and D.W. Taylor. 1971. Spruce beetle brood production in logging slash and windthrown trees in British Columbia. Pacific Forest Research Center, Canadian Forestry Service, Victoria B.C. 16 pages.

Furniss, M.M. 1962. Infestation patterns of Douglas-fir beetle in standing and windthrown trees in southern Idaho. Jour. Econ. Est. 55(4):486-491.

Lejeune, R.R., L.H. McMullen, and M.D. Atkins. 1961. The influence of logging on Douglas-fir beetle populations. For. Chron. 37(4):308-314.